GCE EXAMINERS' REPORTS

GCE
PHYSICS
AS/Advanced

SUMMER 2019

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PHYSICS

General Certificate of Education

Summer 2019

Advanced Subsidiary/Advanced

AS UNIT 1 – MOTION, ENERGY AND MATTER

General Comments

Nearly all candidates attempted to answer all the questions, with few blank script parts seen. The paper contained questions taken from all topic areas within the specification with some questions scoring better than others. The question paper highlighted some gaps in candidates' knowledge, particularly of terms and definitions such as the 'principle of conservation of momentum' and the 'principle of moments', both of which were answered poorly. On the positive side, many (though not all) candidates showed good understanding of practical methods, including the relationship for a straight line and how it could be applied to the situation given, and also of calculating uncertainties.
As in previous Unit 1 papers examiners were very encouraged by the mathematical skills shown by candidates, particularly when resolving vectors and handling equations. Candidates also had opportunities to demonstrate their extended writing skills and they usually did so well, giving, in many cases, good, clear and concise explanations. It was noted however by examiners the increased number of untidy or even chaotic responses, especially from weaker candidates and, more often than not, for questions requiring a 'show that' response.

Comments on individual questions/sections

Q.1 (a) (i) and (ii)

There were very few correct answers seen. The majority of candidates gave partial answers here. Few realised that, for example, all three groups of particles are affected by the weak force.

(b) (i) Nearly all correctly stated anti-(electron) neutrino. The term 'electron' was not required in the answer.

(ii) The majority of candidates were able to show how lepton number is conserved in the interaction. However, fewer were successful in showing how charge is conserved, with many seeming to ignore the beryllium (0 or +4 accepted). A significant minority assigned a charge to the antineutrino.

(c) (i) Nearly all correctly gave the number of neutrons in beryllium and boron.

(ii) The majority of candidates were able to show the change in quark favour from udd to uud.

Q.2 **(a)** The majority of candidate were able to state the difference between vectors and scalars, some in a very 'minimalistic' way, such as: *'vectors have direction'*. This was credited, with the implication being that scalars do not have an associated direction. Examples were, in the main, correct.

(b) **(i)** The majority of candidates were able to carry out the conversion correctly. Weaker candidates did struggle here however, as was evident by their untidy attempts to get an answer close to the 70 $km\,h^{-1}$ given in the question. Consequently, in some case, examiners commented on the difficulty in deciphering some responses. Carrying out simple unit conversions is always worth practising.

(ii) Many candidates completed the graph correctly to show the mean speed over the 8 km. Many were able to do so without showing their calculations in the space provided, and if plotted correctly would have been credited with all three marks. It should be noted however that in questions of this nature, not showing calculations carries a risk, in that if the graph is plotted incorrectly (outside the tolerance of ±1 small square), the candidate would lose all three marks. This occurred on a few occasions.

(c) A variety of approaches were possible here, calculating the initial speed or the expected distance travelled at 30 $m\,s^{-1}$ being two. Many candidates were able to show that the car was travelling at a speed greater than the speed limit. However, a significant minority were penalised one mark for careless use of signs.

Q.3 **(a)** A disappointing response. Few candidates were able to state the principle of conservation of momentum correctly and fully. Many candidates omitted '*total*' or '*sum*' or did not refer to external forces. In some cases, candidates confused momentum with moments.

(b) **(i) and (ii)**

The majority of candidates applied the conservation of momentum correctly to the situation shown. However, a minority of candidates assumed incorrectly that the spaceship would move 'backwards' following the release of the probe. Consequently, they became confused with the use of 'signs' in their equations leading to incorrect answers. Some candidates incorrectly took the mass of the spaceship to be 600 kg **after** explosion. In (ii), most candidates who gained a correct answer in (i) were able to show the increase in kinetic energy. A common, recurring, issue however continues to be that some candidates, when calculating the total kinetic energy of two bodies, add the velocities together in a 'combined' attempt to determine the kinetic energy, rather than finding the separate kinetic energies of the two bodies and then combining these values. i.e. $½ \times m \times (a + b)^2$ (incorrect) as opposed to $½ \times m \times (a)^2 + ½ \times m \times (b)^2$ (correct).

(iii) The majority of candidates did state that the increase in kinetic energy arose from the explosion but few gave the detail required at this level, that it was from the 'chemical' or 'thermal' or 'internal' energy or 'work' from the explosion.

(c) Few candidates were successful in determining F. Some candidates missed the milli-second aspect of the question. Many others made a power of 10 error when determining the probe's change of velocity.

Q.4 **(a)** This question did seem to discriminate between candidates who possessed good trigonometry skills and those who didn't. As in 2(c), answers from weaker candidates were often jumbled and difficult for examiners to interpret.

(b) **(i)** In order to gain the mark a full and complete answer was required relating the increased horizontal component of force to the consequent motion of the skater. Many responses only made one point about the greater horizontal force without the effect this had in terms of creating a resultant force on the skater.

(ii) The majority of candidates gained two out of three marks here. In many cases candidates failed to determine the resultant force correctly but did succeed in using their (incorrect) value correctly to determine the initial acceleration.

(c) This part proved to be an effective discriminator. Weaker candidates failed to grasp the concept being tested and, in most cases, did not pick up any credit. Many candidates did however gain some credit for referring to the equation $P = Fv$ or equivalent. Some attempted answers based on the work done over a specific distance, which was credited. Few candidates proceeded to give full and valid arguments for why the claim was incorrect.

Q.5 **(a)** As in part 3(a), this was poorly answered. Few candidates were able to give a complete and correct statement of the principle of moments. Many defined a moment.

(b) Many understood 'centre of gravity' and were able to quote the definition perfectly. However, few were able to apply their knowledge of the term to this situation. Good diagrams showing the line of action of the centre of gravity lying inside the base of the block were credited along with good explanations. Many vague and ambiguous statements were seen however, such as the CoG 'staying inside the block', which were not credited. The second mark was rarely awarded with only the best candidates referring to the anticlockwise moment restoring the block to the upright position.

(c) **(i)** Nearly all candidates determined all the mean F values correctly and to an appropriate number of significant figures.

(ii) A good response. The majority of candidates were able to show how to obtain the given relationship, especially if they identified that the A.C.M. could be given by $F \times L$ or $F \times 980$.

(iii) The majority of candidates gained full marks for plotting the graph. Appropriate scales, labels and units were seen on most graphs. The most common error occurred with the line of best fit, with many candidates attempting to 'force' it through the origin. In these cases, it was obvious that candidates hadn't picked up on the term $\frac{W_R}{2}$ in the equation in the previous part.

(c) (iv) I and II.

These parts tested candidates' understanding of how the graph related to the given equation and the equation for a straight line. In I. many candidates made reasonable attempts at determining the gradient of their graphs. However, a significant number then failed to multiply their gradient by 980, as required, to find W_B. In a few cases, candidates used the values given in the table, which was not credited. In II. a greater number realised that the intercept represented ½ × the value of W_R and were successful in determining the value of W_R to within the tolerances specified in the mark scheme. It should be noted that in I and II, examiners commented that the units given were often incorrect. This was not tested here but should be noted by teachers when discussing with candidates.

(d) The majority of candidates gained at least one mark for determining the percentage uncertainty in d. Fewer were successful at obtaining the percentage uncertainty in mean F, with the most common error being to not divide the range by 2, so that the values found were double what they should have been.

(e) Many candidates picked up on the procedural information given in the question, that Sam '*judges that the ruler is horizontal by eye....*'. Consequently, many good answers were seen based on techniques to ensure the ruler was horizontal. References to using a digital (or high resolution) forcemeter or repeating the readings for force were also accepted. Many candidates suggested taking more readings of length despite their answer to (d).

Q.6 (a) Examiners were encouraged by the many good responses seen. On the whole candidates were able to describe well, and on a microscopic scale, the materials given. More often than not, two appropriate examples of their chosen terms were given.

(b) The QER question was based on an experiment to determine the Young modulus of a metal in the form of a wire. Responses suggest that this was well received by candidates, as many scored highly. The majority of responses were of middle band quality with reference being made to all three of the areas referred to in the question i.e. **Describe the measurements to be made**, how they should be **used to determine the Young modulus** and **precautions to minimise uncertainties**. A few did not refer to a micrometer/Vernier scale to determine the diameter, and weaker responses tended to refer to 'measuring area' rather than diameter, or quoted radius in the formula without explaining how it was measured. Many explained how to work out the force, which was not needed as it was known, whilst some candidates did not make any reference to the use of the Young modulus formula or graphs of force-extension or stress-strain. Some candidates referred to 'surface area' rather than cross-sectional area. The best responses made correct and full reference to all three areas, providing at least two precautions.

Q.7 **(a)** This question tested candidates' knowledge and understanding of the stellar spectrum - section 6(a) of the specification. This is the first time it has been tested in this way and responses were generally disappointing. Candidates were expected to refer to:

*A **continuous spectrum** [emitted] **from the surface** [of the star].*
*A [superimposed] line **absorption spectrum** [due to the passage of radiation] **through** the **atmosphere** [of the star].*
Note - the wording in brackets is for completeness and was not required as part of the answer, only the parts in bold. The statements reflect closely the statement given in the specification.

(b) **(i)** A significant number of candidates failed to recall the inverse-square formula for intensity. Those that did were usually successful in obtaining the correct answer. Some candidates made no attempt to simplify the ratio once they had substituted their values into the equations. A penalty of one mark was deducted in these cases.

(ii) Only the better candidates realised the relationship between the graph and part (i) of the question. Those that did, understood that the peak of the graph they were expected to draw was $\times$5.7 below the one given. The second mark was awarded for ensuring that candidate drawn graphs were below that of Sirius at all points, regardless of the peak value drawn. More candidates were awarded this mark.

(iii) Many candidates picked up all four marks for determining the surface temperature of Sirius (2 marks) and then using it correctly to find λ_{max} (2 marks). On the few occasions when the temperature was calculated incorrectly, error carried forward (ecf) was applied to determining λ_{max}.

(c) This 'issues'-based question tested candidates' knowledge of multi-wavelength astronomy. The question was carefully constructed so as to allow candidates credit for using the term 'multi-wavelength', though credit was also given for equivalent terms such as 'many wavelengths'. Further credit was given for suggesting that additional information could be gained from using this development in astronomy, with further additional credit awarded for providing extra 'in-depth' information such as suggesting the link between wavelength and temperature. Few could give the extra detail to secure the third mark.

Summary of key points

- Definition based questions, on the whole, were poorly answered. Candidates should be reminded that assessment objectives for this specification will continue to test candidates' knowledge of key facts, scientific ideas, processes, techniques and procedures. The ability to state key principles and have knowledge of 'basic facts' such as the difference between scalars and vectors will be a continued feature of this examination.

- Candidate responses to the practical based question were, on the whole, encouraging. However, a significant number failed to see the link between the expression given and the equation for a straight line, $y = mx + c$. This understanding is fundamental to nearly all practical based questions where a straight line can be drawn, and candidates who do not have an appreciation of this relationship will be at a disadvantage.

- Candidates should be encouraged to consider carefully the unit they provide for calculation-based questions. In each assessment unit, at least one mark is awarded for correct use of units. Examiners decide on the most appropriate question to apply this procedure during the writing stage. In this paper, the unit mark was awarded in Q3(c).

- On the whole, examiners were encouraged by the mathematical competence shown. However, questions which required a correct use of 'signs' (+ or -), were often carried out incorrectly. Q2(c) and Q3(b) were good examples where many candidates were penalised for incorrect use of signs.

PHYSICS

General Certificate of Education

Summer 2019

Advanced Subsidiary/Advanced

AS UNIT 2 - ELECTRICITY AND LIGHT

General Comments

The mean percentage mark on the electricity section (questions 1, 2 and 3) was 51; on the rest of the paper it was 45. The last question, on refraction and fibre optics, had the lowest percentage mean mark. There was little evidence that this was due to candidates running out of time, nor was the question breaking fresh ground. The next weakest answers were for question 4, on light. This contained the QER, about conditions that are required of the light sources in order to observe interference. Sections 5l and 5m of the specification were clearly not very well known.

Comments on individual questions/sections

Q.1 **(a)** **(i)** The single mark was given even for the most minimal statement of Ohm's law: current is proportional to pd. An appreciable minority of candidates did not manage to write this, though there were some excellent full versions of the law.

(ii) Fewer than half the candidates knew that the resistance of a conductor that obeyed Ohm's law is constant. We were often told that resistance is proportional to current, inversely proportional to current and so on.

(b) **(i)** There was a good success rate in calculating the resistance of X from the data given.

(ii) The data in the modified circuit gives a much smaller resistance for X, so X doesn't obey Ohm's law. A minority of candidates carried this through successfully (or used an equivalent method); some did the calculation correctly but failed to draw the correct conclusion.

(iii) Since the resistance of X went down with increasing current, it could not be a filament lamp. This was conceived as a harder mark. The prediction was borne out.

(c) **(i)** Most candidates defined the *transition temperature* of a superconductor successfully. We did not accept "the temperature at which the conductor has zero resistance".

(ii) Any plausible use (such as in power transmission) for a high temperature superconductor was accepted. Only a minority of candidates realised that if the transition temperature was above the boiling point of liquid nitrogen, then immersion in this liquid would keep the material superconducting.

Q.2 **(a)** What does a battery do in relation to charge in a circuit? We accepted a variety of responses such as: does work on the charge, gives the charge electrical energy, pumps the charge round the circuit. All the same many could not offer sensible answers.

(b) **(i)** Most candidates knew that the emfs and internal resistances of the cell added together and calculated correctly the current through the electromagnet.

(ii) **I** Those who used I^2R usually succeeded in finding the power dissipated in the electromagnet; those who used IV sometimes used the wrong V.

II The battery's chemical energy is being used at the rate $EI = I^2(R + r)$ in which E is the battery's total emf and r is its total resistance. The right hand expression was perhaps the more popular starting point, but there was considerable confusion.

(iii) The missing energy goes to random energy – heat, thermal energy or dissipation of energy was accepted – in the internal resistance. Mention of internal resistance was insisted upon for the mark, but it was sometimes omitted.

(c) Whether or not to include the extra cell? Most candidates realised that this needed the same sort of calculation as in (b)(i), but rather more mistakes were made this time.

Q.3 **(a)** The marks were given for heating in a water bath (not with a bunsen flame as some suggested) and adding ice. An appreciable minority seemed unacquainted with this specified practical.

(b) **(i)** A mark was given for drawing a reasonable straight line of best fit, (or commenting on there being little scatter about a straight line), another for noting that the equation given was of the form $y = mx + c$, the last for pointing out either that the graph intercept or the gradient was positive, as the equation predicted. The last mark was often not gained.

(ii) **I** Almost everyone read off the graph intercept and gave a correct value of R_0 with units.

II Many candidates gained credit for finding the graph gradient but dividing through by R_0 was not always done, and the units of α were seldom given correctly. We knew that deducing the units of α would be challenging.

Q.4 **(a)** This QER question tested sections 5l and 5m of the specification. The need for a constant phase difference was not well understood; for example, we were sometimes told that the sources had to have "equal phase differences" or – worth some credit – had to be in phase. Many candidates didn't write about phase or direction of oscillations at all, but, thinking of slits as sources, explained that there must be enough diffraction for overlap to occur. This was considered relevant. On the other hand, many words were wasted dealing separately with constructive and destructive interference. *Examples* of when the conditions would and wouldn't be met were often not given at all.

(b) **(i)** In general the calculation of mean and percentage uncertainty from a set of six readings was well done. The commonest mistake (one mark penalty) was failing to divide the mean of the measurements by 5 to find the mean separation of *neighbouring* fringes.

(ii) The wavelength was usually calculated correctly (allowing ecf on fringe separation) and most candidates realised that the percentage uncertainty in slit separation simply needed to be added to that in fringe separation.

(c) **(i)** Most candidates used the diffraction grating formula successfully, including putting $n = 2$.

(ii) This part tested section 5j of the specification. Many candidates correctly told us that the grating's bright 'fringes' were further apart than the double slits' fringes, but fewer attributed this to the grating's slits being (much) closer together. The relative sharpness of bright 'fringes' from the grating was often not noted at all, and even then, not always attributed to the (far) greater number of slits in the grating.

Q.5 **(a)** The definitions of *work function* were generally excellent.

(b) Most candidates coped very well with this straightforward application of Einstein's photoelectric equation.

(c) **(i)** Many candidates knew that they needed to divide the light energy per second by the photon energy. Extracting the photon energy from the data in (b) proved too hard for some.

(ii) Many did not realise that they needed to divide the current by e. Few stated the assumption that all emitted electrons were collected (and passed through the ammeter).

(iii) The probability of a photon of this frequency ejecting an electron is the answer to (ii) divided by the answer to (i). We accepted a fraction, a decimal or, if indicated, a percentage. Correct answers (allowing ecf) were in the minority.

Q.6 **(a)** Many candidates gave the basic description: black lines on a coloured (or bright) background. Comparisons with the emission spectrum often failed to mention that the dark lines were in the same places as (some of) the bright lines in the emission spectrum.

(b) **(i)** **I** Many candidates correctly stated that energy was supplied to an electron in transition A (*pumping* was accepted), but did not go on to state that this was in order to keep level U populated or to maintain the population inversion.

II Similarly, the relevance of the quick fall to the ground state was not always pointed out.

(ii) Most candidates knew how to calculate the wavelength emitted and many recognised that it was in the infra-red. The conversion from eV to J was sometimes omitted or done wrongly.

(c) Many answers did not go much beyond stating that there was a danger to sight from lasers. The best answers – and there were some very good ones – mentioned such things as the angle dependency of the absorption by polaroid, or the spectacles possibly preventing the bright spot itself being seen, or low power lasers not being a hazard unless pointed at one.

Q.7 (a) (i) Many candidates measured AC and BD and evaluated $v = c \times \frac{\text{AC}}{\text{BD}}$**.**

An equally successful variation was to calculate $t = \frac{\text{BD}}{c}$ and hence $v = \frac{\text{AC}}{t}$. Those who proceeded via angles calculated from measured distances tended to make mistakes. There were many attempts involving ratios of wrong distances. These could not be given any credit.

(ii) The simplest method was to calculate $n = \frac{c}{v}$. Ecf was given on v, the speed of light in the plastic. Those who used calculated angles usually failed.

(b) (i) Most of the successful candidates calculated the time difference between the 120.90 m route and the 120.00 m route and found that it was greater than 4.0 ns. Predictably, a common mistake was to fail to divide c by 1.520, the refractive index of the core.

(ii) Those candidates who realised that 83° was the critical angle at the interface often went on to calculate the refractive index of the cladding correctly.

Summary of key points

- On the whole candidates did a little better on the electricity questions (1 – 3) than on those involving waves and photons.

- Against this, the definition of *work function* was very well known, whereas many candidates could not manage even a minimal statement of Ohm's law.

- Calculations on Young's fringes and the diffraction grating were usually done well, but conditions required of the light sources in order to produce observable interference (5l and 5m of specification) were not well known.

- Many candidates could not work out a wave speed ratio by taking information from a diagram showing refraction of a plane wavefront at a plane boundary (6c in the specification).

- Almost everyone could use Einstein's photoelectric equation to calculate the frequency of incident light, but some found it difficult to extract the photon energy for use in another part of the question – which turned out to be one of several small 'discriminators'.

PHYSICS

General Certificate of Education

Summer 2019

Advanced Subsidiary/Advanced

A2 UNIT 3 – OSCILLATIONS AND NUCLEI

General Comments

The general standard of performance of candidates is to be commended. The statistics indicate that the paper provided good differentiation for the cohort of applicants.

Topics

The weakest topic this year was the particle physics comprehension but, to some extent, this is to be expected due to its synoptic nature. However, this year's mean mark was particularly low. Otherwise, it was the Charles's law experiment (Q1) that proved to be the most demanding.

Language

Examples of good explanations were 2(c), 2(d)(ii), 3(d), 4 while the less successful explanations were 1(c)(ii) and 6(c)(ii)III.

Mathematics

Very few problems with algebra and mathematical skills were encountered again this year and candidates now seem to provide a little more when the question states "Show that".

Practical skills

Uncertainties provided some difficulties again this year. Interpretation and evaluation of results also proved to be difficult.

Comments on individual questions/sections

SECTION A

Q.1 **(a)** Well answered although most candidates only considered the uncertainty at one end of the length measurement.

(b) **(i)** Generally well answered but there are always problems with converting units in this type of question. On rare occasions, incorrect formulas were used.

(ii) When given a target of 15 % candidates will often obtain that value "by hook or by crook". A very common wrong answer was:

Uncertainty in diameter = $\left(\frac{1}{15}\right) \times 100 = 6.7\,\%$

Uncertainty in area = $2 \times 6.7 = 13.3\,\%$

Uncertainty in length = $\left(\frac{0.1}{11.5}\right) \times 100 = 0.9\,\%$

Total uncertainty = $14.2\,\% \approx 15\,\%$ QED

This answer only lost one mark for not considering the uncertainty at both ends of the tube.

(c) **(i)** Well answered but a large minority were unable to come up with (270 ± 20) °C.

(ii) This part question proved to be quite demanding even though two marks should have been automatic responses i.e. straight line and through all error bars. A third mark should also have been awarded more often - simply stating that the intercept was close to -273 °C or absolute zero.

(d) The correct definition of absolute zero and that which the specification states is: "absolute zero being the temperature of a system when it has minimum internal energy". On this occasion we were quite lenient in the marking. Far too many candidates talked only about "decreasing kinetic energy" which is a description of what happens with decreasing temperature whereas the question asked about approaching absolute zero.

(e) Poorly answered. This question was about factors affecting accuracy and not precision. The following answers were common:

The accuracy of the ruler. The accuracy of the thermometer. The resolution of the thermometer. Whereas we were looking for factors such as a temperature difference between the gas and the thermometer or parallax errors in reading the length etc.

Q.2 **(a)** Quite well answered with candidates finding various acceptable methods of defining the radian.

(b) **(i) and (ii)**

Very well answered with only the weaker candidates failing to obtain full marks.

(c) This "explain" question met with excellent responses. Some candidates were unable to calculate the centripetal force or did not realise that the normal contact force provided the centripetal force. A very small minority incorrectly claimed that F = 650 N because it is the Newton's 3rd law reaction force to the weight.

(d) **(i)** Well answered with most candidates obtaining full marks.

(ii) Quite well answered but a common mistake was to assume that the centripetal force (2 600 N) remained constant even though the question stated "as the angular velocity reduces".

Q.3 **(a)** Three quarters of the candidates could name all three variables.

(b) **(i)** Usually very well answered. Obtaining the angular velocity from the period was a difficulty only for a minority.

(ii) Most candidates drew straight lines through the origin with a negative gradient but some did not put a value on the acceleration axis and others were a little careless in where their lines started and ended.

(c) Answers to this simple little question were a little below the expected standard. The amplitude and angular velocity should have been automatic marks (with ecf) but this was not always the case. The majority of responses did not obtain the correct phase angle for the oscillation but this is understandable when the phase angle is $-\frac{\pi}{2}$ or $\frac{3\pi}{2}$ as in this case.

(d) **(i)** Well answered with most candidates providing good examples but it was sometimes difficult for the candidates to identify the oscillator and the periodic driving force.

(ii) Again, well answered with many and varied examples of unwanted resonances. The mark awarded least often was for the explanation of resonance i.e. when the driving force has the same frequency as the natural frequency of the oscillator, large amplitudes will result.

Q.4 This was a good, fair 6 mark QER question with a mean mark just above 50 %. Descriptions of the experiment itself were usually of a high standard. Weaker candidates did not discuss the graphical analysis and relied on using data points to obtain only one value of the acceleration due to gravity.

Q.5 **(a)** **(i) and (ii)**

Very few candidates failed to obtain the correct answers to these questions.

(iii) Obtaining the correct rms speed is full of pitfalls, the most common being not using the correct "m" or not using the correct "n". When a speed of ~10^{14} m s^{-1} is encountered, it has obviously arisen from using a molecular mass with the number of moles. If a speed of ~10^{-10} m s^{-1} is calculated, it has obviously arisen from using a molar mass with a number of molecules. If the answer is out by a factor of $\sqrt{1000}$ (obtaining 15 m s^{-1} instead of 471 m s^{-1}) then the candidate has failed to convert from gramme to kilogramme. If a candidate has obtained an answer around 220 000 m s^{-1}, they have forgotten to take the square root at the end.

(iv) Very well answered.

(b) **(i)** Very well answered either by using Boyle's law or the ideal gas equation.

(ii) Many candidates failed to mention that the change in internal energy was zero.

(iii) Although quite tough, the responses to this part question were encouraging. Candidates could obtain the correct answer by two different methods - calculating the work done for each stage or calculating the area of the closed "triangle". Those who knew what to do invariably obtained the correct answer but a minority became stuck and unsure of how to proceed.

Q.6 (a) (i) and (ii)

Very well answered with the vast majority obtaining full marks as one would expect.

(b) Tougher than usual because the atomic mass of strontium was given. Hence, the most common omission was not to subtract the mass of the electrons. Another common omission was to forget to divide by the nucleon number after having done everything else correctly.

(c) (i) Almost universally correct.

(ii) I Well understood but a difficult point to explain fully.

II A significant minority only obtained $(0.75)^n$ and omitted multiplying this by the original number of dice.

III Quite a difficult explanation and only a minority of candidates realised that the answer simply involved discussing the last column of the table and randomness.

SECTION B

Q.7 Rather unexpectedly, this comprehension passage has led to the lowest mean mark ever for such a 20 mark question. There were many standard calculations in Q7 but these calculations have not been expected for some years probably because of the synoptic nature of the calculations.

(a) Most candidates realised that $F = Ap$ was required but a very common error was to use $A = 4\pi r^2$ (for 1/2 marks) rather than $A = \pi r^2$. This is a subtle point but it must be the cross-sectional area when the hemispheres are pulled in opposite directions.

(b) Surprisingly few candidates realised that this was about electrons/particles colliding with molecules.

(c) (i) Although this is a standard calculation (for unit 4) it was very rare to encounter a correct answer here. Even applying conservation of energy (KE→PE) proved too difficult for most. Converting the 4.7 MeV to J was the most common mark to award.

(ii) Very few good answers were seen here.

(d) Although calculating the de Broglie wavelength of a 4 keV electron is a standard calculation, it is made difficult because one would expect this calculation in unit 2. Also, this question was set out as AO3 which made it even more difficult.

(e) Only 40 % of the candidates realised that proton-proton repulsion was the answer required here.

(f) Again, these were difficult AO3 marks but the mean mark was far lower than expected. Calculating the momentum of both the electron and photon are very easy, one step calculations but very few candidates thought to do this. Conservation of momentum was stated in the question, so why did so few candidates calculate these momenta?

(g) Very well answered with only around 20 % of the candidates not remembering their unit 2 work.

(h) Again, well answered with most candidates obtaining full marks. Those not obtaining full marks usually made only a minor slip in one of the conversions.

Summary of key points

In short, some areas of improvement that might benefit your candidates:

- Be prepared for the synoptic nature of the questions based on the comprehension passage.
- Practice how to obtain final uncertainties from multiple measurements and graphs.
- Learn the standard evaluation phrases for graphs - "line passes through all error bars", "straight line", "passes through origin", "lines straddle origin", "points are close to line of best fit (if no error bars)", "agrees/disagrees with theory/equation".
- Remember the graphical analysis of the specified practicals.
- Easier said than done but try not to confuse n, N, N_A, m, M, m_r in kinetic theory.

PHYSICS

General Certificate of Education

Summer 2019

Advanced Subsidiary/Advanced

A2 UNIT 4 – FIELDS AND OPTIONS

General Comments

The general standard of performance of candidates is to be commended. The statistics indicate that the paper provided good differentiation for the cohort of applicants.
Topics. The weakest topic this year was magnetic and electric fields (Q4) but this was rather a tough question.

Language. Examples of good explanations this year were 1(a)(ii)&(iii) and, to some extent 5(b) the QER. The less successful explanations were tough this year and were 1(c), 2(b)(iii) and 4(a). This year, marks were not usually lost due to poor communication skills but rather, because the physics itself was difficult to explain.

Mathematics. Very few problems with algebra and mathematical skills were encountered again this year and candidates now seem to provide a little more when the question states "Show that".

Evaluative questions. One instance of good answers - 1(a)(iii), while others proved to be difficult 1(c), 2(b)(iii), 4(c)(i) and 4(d).

Practical skills - These were good this year with 1(b) providing a particularly high mean mark.

Comments on individual questions/sections

SECTION A

Q.1 **(a)** **(i)** Very well answered. It could be argued that starting the paper with a three-step calculation is a little unfair but the mean mark would suggest otherwise.

(ii) Well answered generally and candidates had no problem in explaining the separation of charge. Explaining why this separation of charge results in energy storage was a little less successful. A simple "stores potential energy" would have sufficed.

(iii) The responses to this year's issues questions were excellent.

(b) **(i)** Tricky but quite well answered. Understandably, some candidates were unsure how to obtain the uncertainty.

(ii) Almost universally perfect.

(iii) Very well done indeed. It was rare to award fewer than four marks out of five. The most common mark to lose was for the quality of the line of best fit - some double lines (or hairy) were encountered, some were not smooth enough, some lines were too low while others were too high but it was pleasing to see no horrible "dot-to-dot" efforts.

(iv) Surprisingly few candidates approached this by the easy method. Candidates should be encouraged to remember the 63 % rule i.e. one time constant means 63 % charged (or discharged). Those who knew the rule obtained these marks very easily.

(v) This is a skill that nearly all candidates carry out impressively at this level. Unfortunately, many candidates lost a mark for not realising that the charge was in mC.

(c) A difficult evaluative question but the mean mark was reasonable. There were some obvious, standard answers here that would score points - the line passes through all error bars, the shape of the graph is in agreement (with the charge equation). Other marks were more difficult and required some analysis.

Q.2 **(a)** Extremely well answered and the highest mean mark on the paper.

(b) **(i)** Very well answered but a minority subtracted the potentials rather than adding them. Did they believe that potential was a vector? A small minority insisted on trying to obtain the potential energy for no marks.

(ii) Very well answered although a small minority insisted on trying to use the force equation and not being able to proceed.

(iii) Quite poorly answered and it was very rare to award all three marks. Most good answers only obtained two marks for answers based only on the proportionality of the force (wrt displacement) and not considering the direction of the force. Other good (or even better) answers only answered in terms of the direction of the force without referring to its proportionality (wrt displacement).

Q.3 **(a)** **(i)** Well answered with most candidates knowing Kepler' laws.

(ii) This was also well answered. On this occasion we were lenient with those candidates who started from the equation: $T = 2\pi\sqrt{\frac{d^3}{G(M_1+M_2)}}$ because the question did not force the candidates to start from Newton's gravitational law and the equation for centripetal motion (although there was a strong hint to do so).

(b) Well answered. The answer was obtainable using Kepler's 3rd law (using ratios) or by substitution into the period equation (using the mass of the Earth from the previous question). Those who substituted into the equation found the answer far more easily.

(c) A little more problematic. Obtaining a suitable orbital radius was the main problem with some very unusual choices for the radius. Stating a suitable assumption proved slightly problematic (the best assumption seen was to take the Earth's radius +100 km for the atmosphere).

Q.4 **(a)** Surprisingly poorly answered. All three of the marks proved to be difficult to obtain. Disappointingly, many candidates thought that the equation: $F = BIL\sin\theta$ was relevant.

(b) This was a difficult question but well answered. The direction of the forces seemed to be the most difficult mark to obtain.

(c) **(i)** This is a very difficult question testing AO3 skills, however the responses were encouraging. The best method was to obtain the radius if curvature assuming a uniform field (3.56 cm) and then conclude that the field couldn't possibly be uniform over that distance.

(ii) Nothing complicated was required here and this was answered quite well. One mark was for starting the path in the right direction, the second mark was for curving downward.

(d) Another very difficult AO3 question. Obtaining the electrical force ($F = \frac{Vq}{d}$) proved to be the most difficult step.

Q.5 **(a)** For such standard definitions the mean mark was surprisingly low. Candidates should be encouraged to study the terms and definitions.

(b) In general, responses were quite good for this tough QER and the mean mark was typical for QER questions. The most frequent weakness with responses was jumping straight to an induced magnetic field that opposes the change without referring to changing flux, emfs or current.

(c) A tough question that was, once again, surprisingly well answered. It is strange that a problem based on magnetism has a solution with no magnetic equations involved. The energy starts off as gravitational potential and ends as internal energy, anything else can be ignored. By far the most common mistake was assuming that the "m" in both mgh and $mc\Delta\theta$ were the same but the former was the mass of the magnet while the latter was the mass of the tube. Note that the length of the tube here was irrelevant but we provided it to simplify the calculation.

SECTION B

Q.6 – Option A – Alternating Currents

The mean mark was disappointingly low this year. No particular reason is apparent for this and it is felt that the question was neither difficult nor unpredictable. Perhaps the most telling factor is that the phasor diagrams in part (a)(i) were not as good, generally, as they ought to have been.

(a) **(i)** Not particularly well answered. Those candidates who provided good answers invariably started from a good phasor diagram. Those who didn't struggled to score any marks at all.

(ii) This question was generally well answered even by many of those who failed to score marks in the previous part.

(b) **(i) and (ii)**

Simple one step calculations and were well answered. However, a significant minority couldn't even answer these parts.

(iii) This was tricky because the frequency must be obtained from the reactance of the capacitor. Understandably, many candidates failed to obtain an answer here and many went automatically to the equation: $f = \frac{1}{2\pi\sqrt{LC}}$ which was of no help.

(iv) Again, this part was tricky but often because the candidates did not have a value of frequency from the previous part. Some savvy candidates deliberately wrote "f = 100 Hz (for ecf)" at the end of the previous part to remedy this.

(v) Most candidates were able to explain that the current decreased because the impedance increases although a small minority used the wrong word and stated incorrectly that "the resistance increases". Fewer candidates were able to explain why the impedance increases.

(vi) This part was poorly answered. Of those candidates that drew the pd 90º out of phase, about half of them got the phase wrong and drew the pd 90º ahead. Only a minority was able to obtain the correct peak pd.

(c) By this part, 630 candidates had reduced to 480. Most candidates attempting this part calculated the reactance of the inductor and found that it had the same value as the resistance (43 Ω). Unfortunately, most of those then went on to conclude that the 12 V was shared equally (6 V each) and that the statement was correct. It is important, once again, to use a phasor diagram here to obtain the correct pd of $6\sqrt{2}$.

Q.7 – Option B – Medical Physics

(a) **(i)** Generally poorly answered which was rather surprising, many obtained the first two marks for X-rays penetrating tissue but not bone however very few went on to talk about how the X-rays were detected e.g. affecting photographic film/photo cells. A number of candidates discussed cost but this was ignored, also surprisingly some candidates thought X-rays produced gamma rays.

(ii) **I** There were a number of blank responses to this, however many candidates obtained full marks.

II This was generally well answered although a small minority thought 0.5 % could be found by multiplying by 0.05 rather than 0.005 and so lost the second mark.

(b) **(i)** This was generally well answered which was not surprising as the derivation is identical to that for half-life and also the half charge of a capacitor. The main problem was that negative signs seemed to be dropped/forgotten about for no reason.

(ii) Again generally well done the main problem, for a minority of candidates, was not stating if they were working in metres or centimetres.

(c) A number of candidates were too general / vague in their descriptions with no explanations being given e.g. just stating ‘this is good / this won’t work’ without giving any explanation as to why. Some candidates talked about the speed / time it takes for the test and also the cost of the test, both of these points were ignored. Many candidates missed the importance of taking ‘real time’ images and some missed fluoroscopy out of their description all together.

(d) **(i)** Generally well answered, however some explanations were too vague e.g. ‘dose equivalent depends on the type of radiation’ without mentioning the weighting factor, also the absorbed dose was the amount of radiation received by the person, not specifying per kilogram.

(ii) As expected many candidates forgot to include units.

Q.8 – Option C – The Physics of Sports

Candidates attempted all parts of the question with part (b)(v) proving to be the most discriminating part. Surprisingly part (b)(iii) was poorly answered with many candidates not able to determine the angular velocity or the moment of inertia correctly.

(a) **(i)** In general, this definition was not answered well with many candidates referring to the ratios of bounce height and not using the 0.55 in their answer.

(ii) This part was answered well though the common error was not to use the reduction in the value of coefficient of restitution correctly.

(b) **(i)** This was answered well by all candidates.

(ii) This was also answered well by all candidates.

(iii) As noted previously; this part proved to be difficult with common mistakes in determining the moment of inertia using the diameter rather than the radius. Also the squaring of the various quantities was omitted in incorrect answers as well as not being able to determine the angular velocity correctly.

(iv) The common errors in this answer were that candidates referred to the potential energy. Some candidates did determine the total kinetic energy numerically.

(v) Only the more able candidates were able to gain full marks on this part. Some candidates used an approach based on the drag force equation though the question did state that candidates were to use the Bernoulli equation.

Q.9 – Option D – Energy and the Environment

(a) **(i)** A significant number of candidates were unable to recall the Archimedes' principle correctly. Some made reference to an upward force, however, this force, buoyancy or upthrust was not always related to the weight of fluid displaced.

(ii) The mass of salt was often correctly calculated by candidates. There were a small number of candidates who made power of ten errors.

(iii) Most candidates either correctly stated the mass of ice correctly or used this mass correctly to find the volume of the ice cube. A smaller number went on to calculate the volume above the surface. There were alternatives shown by candidates who achieved all three marks. These included the use of densities to calculate the % of mass above the water. Others candidates calculated the mass below the surface and subtracted this from the total mass leading to the correct volume above the surface.

(iv) **I** Candidates who had clearly considered units within this question part were able to achieve this mark. There were a number of candidates who incorrectly calculated the inverse of this.

II Most candidates explained that the melting ice sheet would indeed add volume to the sea. A smaller number made reference to the melting iceburg replacing the sea water it had already replaced.

III Candidates produced good responses regarding absorption and reflection, some including reference to albedo.

(b) **(i)** This question was generally well answered by candidates. Most correctly chose the thermal conductivity equation and went on to show convincing algebra. As an example, the cancelling of m's was regularly seen. A small number of candidates were unable to state the unit of Q correctly sometimes confusing this with charge.

(ii) Most candidates correctly used the thermal conductivity equation here. There were a minority of candidates that made power of ten slips and a small number of candidates incorrectly added 273 to their temperature difference.

(iii) This proved to be a challenging question part. Some candidates realised that the heat flow was the same through both layers. These candidates invariably went on to set up an equation in order to find the temperature at the boundary, however, algebraic errors often prevented the third marking point to be gained. The final marking point allowed for ecf and candidates were able to gain credit with their conclusion if they correctly interpreted the 60 % decrease.

(iv) Some candidates who attempted this question drew straight lines with a negative gradient. Candidates who achieved both marking points realised there was a change in gradient at the boundary between materials.

Summary of key points

In short, some areas of improvement that might benefit your candidates:

- Use the 63 % rule for the time constant when charging/discharging capacitors.
- Remember that the potential field is a scalar field and has no direction.
- Learn the standard definitions from the terms and definitions booklet.
- Practise more of the evaluative (AO3) type questions. At first, they can seem daunting because they can be approached in many ways and choosing an approach is often the most difficult step. However, as in most things, practice makes perfect.

PHYSICS

General Certificate of Education

Summer 2019

Advanced Subsidiary/Advanced

A2 UNIT 5 – PRACTICAL EXAMINATION

General Comments

The experimental task and the practical analysis task were generally well answered with the vast majority of candidates having been well prepared for the examination.

Comments on individual questions/sections

EXPERIMENTAL TASK

(a) The vast majority of candidates took logs of the equation correctly with only a few candidates then failing to identify which graph they were going to plot.

(b) **(i)** The diagram was generally well drawn and correctly labelled with only a few failing to label the main components. However, unfortunately only a minority of candidates gave trial readings in their plan. The method was generally well done and it was felt that there was an improvement on previous years with the majority of candidates specifying the range of weights they were using and also the number of oscillations along with how many repeat readings they intended taking.

(ii) The risk assessment was teacher assessed and in the majority of cases correctly carried out as there was minimal risk associated with the experiment. We did not accept the masses falling off as a risk because there was a maximum of 500 g and also we did not accept the masses flying up in the air and hitting you in the eye, consequently goggles were not required.

(c) Some candidates did not repeat timings for the oscillations and so were not able to calculate a mean timing, losing this mark. The vast majority of candidates calculated the log values correctly and gave them to two significant figures. A few candidates forgot to include the resolutions of the stopwatch and ruler. The resolutions were accepted both in the table or separately either above or below it.

(d) As for previous years the graph was very well done with the candidates obviously having practised, and been well taught, this exercise.

(e) Most candidates identified n as being the gradient and went on to calculate it correctly. Many candidates identified log k as being the intercept on the y-axis. However when log k needed to be calculated, because it could not be read directly from the graph, a point on the graph should have been used, a minority of candidates instead, incorrectly chose a point from their table.

(f) **(i)** It was pleasing to see that a large number of the candidates identified n as being 0.5 and correctly compared it to their own value for the gradient. A smaller number, as expected, were able to identify k as $2\pi g^{1/2}$ and then compared it to their value for k.

(ii) Most candidates were able to correctly specify how to reduce the uncertainty in the results with the majority stating that a larger range of masses was needed.

PRACTICAL ANALYSIS TASK

Q.1 This question was generally well done with the majority of candidates being well taught in answering questions of this nature. Some candidates did, however, give incorrect units for the density and a number quoted the uncertainty in the density to more than two significant figures.

Q.2 **(a)** In the table most candidates correctly calculated the values for mean diameter and also the mean diameter squared. However, a significant number were unable to, correctly, calculate the uncertainties in both the mean diameter squared and the impact velocity.

(b) Again the graph was generally well drawn in particular in drawing lines of maximum and minimum gradient. This showed a real improvement from previous years. A small minority did not use a scale such that the points (including error bars) occupied over half of each axis.

(c) **(i)** The gradients were generally calculated correctly with the majority of candidates drawing a large enough triangle or identifying suitable points on the graph.

(ii) In almost all cases the mean gradient was calculated correctly. There was no unit penalty for this calculation. As with question 1 a number of candidates, unfortunately, gave the percentage uncertainty to more than two significant figures.

(iii) Many candidates only obtained one mark out of the two available, usually for stating that the graph was a straight line unfortunately they did not go on to state that it had a positive gradient or to discuss the y-intercept.

(d) A number of candidates stated that the crater would be smaller but did not specify that the diameter would reduce. Few candidates were able to calculate by what factor the mean diameter or the impact velocity were reduced.

Summary of key points

Experimental task

- Candidates were generally very well prepared for this task. Almost all were able to convert the power relationship to logs and state which graph should be drawn. The graph and results table were also particularly well done.

- The method writing this year showed a significant improvement, however a number of candidates did not include trial readings when deciding their ranges and sample size.

- In some cases the y-intercept could not be determined directly from the graph and needed to be calculated. This could be done using a point from their graph but not a point from their results table.

Practical analysis task

- The graph was generally well done and pleasingly so were the lines of maximum and minimum gradient, this was a significant improvement on previous years.

- A number of candidates lost marks by quoting the percentage uncertainties and / or the absolute uncertainties to more than two significant figures.

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