GCE

Rewarding Learning

Chief Examiner's Report

Physics

Summer Series 2022

Foreword

This booklet outlines the performance of candidates in all aspects of this specification for the Summer 2022 series.

CCEA hopes that the Chief Examiner's report will be viewed as a helpful and constructive medium to further support teachers and the learning process.

This booklet forms part of the suite of support materials for the specification. Further materials are available from the specification's microsite on our website at www.ccea.org.uk.

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GCE Physics

Chief Examiner's Report

Subject Overview

In general, at both AS and A2 level, the performance of candidates at the top grades was similar to previous examination years. The range of marks achieved appeared to be considerably higher though with lower grade candidates on a lower raw mark than previously would have been the case. A few examiners reported evidence of synoptic content being poorly answered in A2 papers, possibly across more candidates than pre-covid although this has always been an area of weakness in A2 papers.

Poor handwriting in written responses is a major difficulty. Candidates should be aware that they should score out and write fresh answers rather than overwriting numbers as it is impossible to decipher overwritten numbers especially when the paper has been scanned. Disorganised layout of working in unstructured calculations continues to create problems. Where the correct answer has not been achieved and examiners are trying to award credit for candidates working it is difficult on those scripts where the working is unclear. Points on graphs or lines on grids should be clearly marked so that they can be identified after the scanning process.

Candidates should be reminded that whilst past papers and their mark schemes are useful tools, they should not be reliant upon the mark schemes for learning answers. Knowledge must be applied to the specific question asked. Evidence of careful reading and interpretation of the question is missing in many responses. When a definition is required, candidates should ensure that their responses are unambiguous and could not be interpreted in a different way than they intend.

When performing calculations using given data it is expected that candidates should quote their answer to a suitable number of significant figures. While not doing so will not be penalised in every question it is expected as good practice and will, on occasions where it is relevant, be penalised. Answers should also be given on the answer line rather than working out shown leading to an answer and the answer line left blank.

In questions where candidates are asked to 'show that..' there should be a clear starting point from first principles and it should be obvious at each step what the candidate is doing. There should be no jumps or skipping steps. Even though it may be obvious that the candidate knows what they are doing, the purpose of these questions is to assess whether they can explain the physics behind the calculation or derivation. Lack of structure will result in loss of marks. If there is a numerical value being calculated, the value should be quoted to one more significant figure than the value given in the question.

Assessment Unit AS 1 Forces, Energy and Electricity

Overview

In general, candidates performed very well in this paper. Many candidates scored high marks and there were relatively few scoring low marks. The range of marks was from 4% to 99%. The paper was very accessible to almost all candidates and most candidates were able to demonstrate a sound understanding of the physics involved in this unit. There was some evidence to suggest that a small number of candidates had insufficient time to complete the paper.

The paper appeared well balanced and addressed most topics on the AS 1 specification.

The questions that were the most discriminating were Questions 1(c), 2(a)(i), 3(b)(i), 4(b)(iii), 5(b), 8(a), 8(b) and 8(c). The paper was, however, successful in allowing candidates of differing abilities to respond positively to most of the questions posed.

Q1 **(a)** This was generally well answered but some candidates stated magnitude and direction suggesting that they thought they were being asked about a vector quantity.

(b) This was well done but some candidates did not follow the instructions and gave the base units for all quantities rather than the SI units required. A significant number of candidates incorrectly gave the ampere as the SI unit for charge.

(c) This was either very well done or poorly completed. Some candidates started with V=IR and found it difficult to progress to the answer. Transcription errors to the answer line often caused a mark to be lost.

Q2 **(a)** The vector diagram caused difficulties for the many candidates. Vectors V and Vc were often mixed up. If vectors were drawn from a point, they often did not form a right angle and the first marking point was not awarded. Incorrect vector diagrams in Part (i) usually meant that candidates were not able to score marks in Part (ii). A good discriminator.

(b) Part (i) was well attempted, but a few candidates used $V=1.8ms^{-1}$ even though their vector diagram in Part (a) was correct. Many candidates scored full marks in Part (iii) and benefited from an ecf.

Q3 **(a)** The principle of moments was not always accurately stated in its entirety. It was either very well stated or one of the three marking points were omitted.

(b) The majority of candidates struggled to correctly set up an appropriate equation with all three elements correct. Most were able to get at least two of the three elements correct. Many forgot to consider the weight of the mobile. A significant number of candidates did not set out their work clearly and it was sometimes difficult to establish where they had taken moments from. Part (ii) was well done though a few candidates answered 'yes' indicating they had not read the stem of the question.

Q4 **(a)** Vertical and horizontal components of the initial velocity were calculated correctly by most. Some rounding errors caused the loss of a mark here. In a few cases, the components were mixed up. Many candidates were able to use their components in a correct equation of motion and score full marks in Parts (ii) and (ii).

(b) Candidates found this part more challenging. The definition of impulse in Part (i) was poorly stated with many giving an answer in terms of momentum. Part (ii) was well attempted by the majority. However, a significant number of candidates were unable to convert kg to mg. Part (iii) presented a significant challenge to many candidates and discriminated well. Many failed to recognise that there were two parts to the motion each with a different horizontal velocity and lost marks. In this case, candidates usually only scored the first mark for use of $s=ut+ ½at^2$ with a=0. A few candidates attempted to use the range formula. Part (iv) was well answered.

Q5 **(a)** The vast majority of candidates were able to correctly show multiplication by 1609 and division by 3600 in Part (i) but many did not show their answer to the extra significant figure required. In Parts (ii) and (iii) most candidates were able to correctly draw the v-t graph and state how to determine the distance. Part (iv) was a challenge to some candidates. However, the vast correctly calculated the distance travelled. Some candidates failed to correctly incorporate the distance to the third arresting wire.

(b) This part was very poorly answered by most candidates and was thus a good discriminator. Whilst Newton's third law was well known, very few candidates correctly explained how it applied to the hovering jet. Most referred to a reaction force from the ground or the aircraft carrier and were unable to identify the exhaust gases as body B. Many candidates introduced a third body or referred to weight.

Q6 **(a)** This part was well answered by the majority.

(b) Most candidates were able to define resistivity correctly in Part (i). The calculation was generally well done but a number of candidates divided the length by three. 10^n errors in the calculation of the cross-sectional area were also evident in some scripts. Most candidates correctly identified that the resistance would increase but failed to mention that this would cause the wire to heat up. A significant number of candidates thought this would reduce effectiveness of a shower.

Q7 **(a)** This part was generally well done but some diagrams were poorly drawn. A few candidates included a fixed resistor as the load instead of a variable resistor. Some candidates were unable to position the voltmeter correctly.

(b) The description of the experiment was well done by most candidates. Some did not state that the experiment had to be repeated for five values of R and lost the last mark. Many explained how the results would be processed, despite not being asked to do so.

(c) This part was well answered by the majority. A few candidates gave incorrect labels on their axes but appeared to have remembered the shape of the graph.

(d) This part was well answered by those that had correctly answered Part (c). A few candidates did not score the last mark.

Q8 **(a)** This part was very poorly answered by most candidates and was thus a good discriminator. Many candidates did not appreciate that the total resistance of the circuit included the internal resistance of the battery and assumed that the total resistance was 50W. Many used the wrong value of voltage for the output voltage. Some calculated the current in the circuit correctly but were unable to take this further. Only a few candidates scored 4/4 in this part.

(b) Most candidates correctly identified that V_{out} would increase and that this was due to the decrease in resistance of the NTC thermistor. Few were able to fully explain that this decreased the voltage across the thermistor. Answers lacked detail in many cases.

(c) Many candidates struggled to obtain the mark for this part. Few candidates gave adequate detail of a description for a use of the potential circuit. Many answered in terms of a system that would activate on cooling rather than heating. Many also stated a use with no description.

Assessment Unit AS 2 Waves, Photons and Astronomy

Overview

The paper was accessible to candidates of all abilities, with the weakest being able to access some marks in all questions. Most candidates provided detail of their calculations in the space provided, although not all laid this work out in a clear and coherent manner. There is some evidence that candidates are perhaps not aware of the need in 'show that' questions to give the calculated answer to a greater number of significant figures. The continuous prose answers were generally attempted to a reasonable degree, although there is evidence of many lacking clarity in regard to explaining key concepts. There was evidence of learning of key definitions across all sections of the specification, with some loss of detail for the longer (2 mark) examples. In the more challenging calculations where six marks were available, weaker candidates could not access marks where higher levels of understanding were required, and there were a few key misunderstandings when the question context was not typical (two-slit interference for sound waves rather than light waves, for example). There were few scripts where candidates left sections unanswered.

Q1 **(a)** Candidates were generally successful with recall of the definition, but many had not used the term oscillations/vibrations as being perpendicular to wave direction.

(b) Candidates had in some cases referenced the wave being in only one plane, neglecting to refer to the oscillations/vibrations being confined to one plane.

(c) The majority of candidates calculated the time period correctly, almost all of this included evidence of their calculation. A significant number had not recognised the milli-second prefix on the x-axis and had therefore incurred a 'power error' penalty for labelling the x-axis as 0.4 and 0.8 rather than 40 and 80 as required. Most wave diagrams were of good quality, with two complete sinusoidal waveforms.

Q2 **(a)** Three well-defined stages of the calculation were required, with the final mark being awarded for sight of the answer to a minimum of two decimal places. In many cases, candidates had not distinguished between the stages of their calculation.

(b) Both Parts (i) and (ii) of the question were generally well-answered by those who identified the correct equations from the data and formulae sheet, with the most common misunderstanding occurring in relation to the use of Hubble's Law to calculate recession speed. Errors were carried forward within the question as necessary.

(c) Part (i) was usually well-answered, with a power error relating to the nano-metre unit on the answer line in some cases, but very few candidates had included the necessary detail of the factor of 1000 in their answer to Part (ii).

Q3 **(a)** The definition of work function was correctly given by many – a small number of candidates lost a mark for not including 'minimum' energy, or for referencing electrons escaping the atom, rather than from a metal.

(b) The calculation was mainly well done.

(c) In Part (i) the first mark for correct identification of the nano-prefix was almost always awarded. Substitution into the equation posed a challenge for many, and there was discrimination between differing abilities in this part. There were a good number of candidates who did not subtract the correct value of work function from their calculated photon energy value. A small number of candidates arrived at a negative kinetic energy value, from which they could not be credited for calculating a velocity. In Parts (ii) and (iii) candidates were generally awarded full marks, with references to either the threshold frequency or the work function in Part (iii).

Q4 Candidates generally scored 3 or 4 of the 5 marks. Most frequently missing from the answers was the reference to electrons existing in specific/discrete energy levels. Marks were not awarded for explanation of absorption of energy rather than emission, in cases where candidates had not read the question with enough care. There was a very large variation in the quality of written communication, with evidence of many candidates being inaccurate with their use of correct physics terms and some candidates not making a satisfactory effort to write coherent sentences.

Q5 **(a)** The majority of candidates were well prepared for this question and achieved three or four marks for the ray diagram, correctly locating the image and identifying it with an upright arrow. Some neglected to include the arrows on the rays.

(b) There was a range of answers to this calculation involving the lens equation. Having identified the magnification as 22, a significant number of candidates incorrectly found a value of u (for many this was 77) and substituted this into their equation, allowing them to achieve three of the four marks. Many candidates used one or both of the object/image height values in the equation, from which there was no error carried forward, as they had not read the question stem with sufficient care. There was a very small number of candidates who included a negative value for either their u or v value.

Q6 **(a)** In most cases a satisfactory explanation was given, referencing both the increased length of time electrons may spend in this level and the fact that it is an excited level.

(b) Here again most candidates gave an adequate answer, in most cases stating that there are more electrons in this level than in the ground state.

(c) In many cases, candidates ignored the request to relate their answer to laser action and referenced a constant phase difference, rather than (photons) being in phase, and most gave additional information about wavelength/frequency.

(d) Few candidates failed to correctly explain monochromatic.

Q7 **(a)** In Part (i) many candidates identified this as a metal or graphite foil or film or crystal, as required. A good number identified it as a diffraction grating, which was not credited. In Part (ii) the majority of candidates used correct terminology of concentric circles or rings, with a small number including a diagram. The fluorescent screen was correctly identified, and in a small number of cases phosphor screen was accepted, but not phosphorous. In Part (iii), the majority correctly referenced electron diffraction, or interference or superposition, as evidence of their wave nature. Very few candidates correctly explained the particle nature as shown by acceleration in the electric field, with some referring to the photoelectric effect and many making no attempt to explain the particle nature.

(b) In Part (i) most candidates achieved four marks. A small number gained a mark for knowing the formula for calculating momentum as mass times velocity and could only follow from this if they had clearly substituted a mass value multiplied by the given velocity. For Part (ii) there were answers of both X-ray and gamma radiation, with error carried forward from an incorrect wavelength.

Q8 **(a)** A wide range of answers was given here, with the minority of candidates gaining the full three marks. For the first mark, the order of diffraction, order number or order of maxima was awarded. For the second mark, the slit separation or distance between slits or lines on the grating was awarded, but 'grating element' without further explanation was not. To achieve the third mark, a clear explanation of where the angle is measured was required and not merely 'angle of diffraction' or 'angle between orders'.

(b) The majority of candidates recognized the value of d, most without a power error, for the first two marks. Subsequent marks were gained for using either the diffraction grating equation or the two-source interference equation from the formulae sheet, to arrive at either 1.11 or 1.12 metres for six marks. A common standard error was to calculate for only one first order fringe (rather than both), giving 2.22 or 2.24 metres for five marks.

Q9 **(a)** In Part (i) most candidates recognised the defect as hypermetropia, and a misspelling as 'hypermytropia' was not accepted. In Part (ii) a satisfactory explanation relating to the lens, or the muscles was most often given, there was error carried forward from Part (i) for those who explained a cause of myopia. The meaning of far-point was mainly correctly explained, with some giving a typical value of 25 centimeters, and in some cases, candidates had not referenced the nearest point for a clear or focused image.

(b) The majority of candidates achieved three or four marks for their diagram, with a common error being a failure to draw the lens on the dotted line or a failure to accurately show convergence of rays after passing through the eye lens. Almost all candidates drew straight lines carefully and gained the final mark for rays meeting on the retina. In the case where a diverging lens was drawn, there was an error carried forward for the second mark.

Q10 **(a)** It was a challenge for candidates to achieve both marks, and in many cases, there was no reference to the two waves meeting at a point. The detail of 'resultant' displacement was missing in a good number of cases.

(b) In Part (i) most candidates were awarded the mark for referencing constructive interference. The detail of zero path difference was required for full marks, and in many cases, this was missing – candidates could gain the second mark for explaining that the waves arrived in phase because of travelling the same distance. Part (ii) provided a good level of challenge for many and discriminated between candidates. The first mark for identifying the mean value of 43 centimeters was usually awarded. Most candidates attempted substitution into the two-source interference equation, but many did not correctly calculate the value for wavelength. The final mark was independent, for recording of their answer to two significant figures, but a considerable number of candidates did not gain this mark.

Q11 **(a)** Candidates generally achieved both marks for this part – the first mark was awarded for sight of two steps towards calculation of the angle, usually the equation relating n to the critical angle and a substitution. The second mark was for evidence of the critical angle calculated to at least one decimal place.

(b) In Part (i) both marks were generally awarded here, as candidates had to reiterate the information given in the question stem, that total internal reflection had occurred, and explain it by stating that the incident angle is greater than the critical angle. The second mark was also awarded to candidates who correctly explained that the light was travelling from a more to a less dense medium. In Part (ii), most candidates followed the instruction to draw a normal line, although not all of these were to a high degree of accuracy and benefit of the doubt was given. Most had drawn a reflected ray within the diamond for a second mark, but only the minority had calculated and labelled the incident angle correctly for the final mark. The first mark in Part (iii) was usually awarded for stating that the incident angle is smaller than the critical, and to achieve the second mark candidates could either explain that refraction had occurred or show this on their diagram. It was not sufficient to state that total internal reflection did not occur.

Assessment Unit AS 3A — Practical Techniques and Data Analysis

Overview

This component was an optional component in 2022 and only a few centres opted to complete this component. The standard of responses across these centres was generally good and most candidates were well prepared for the examinations. Although some appeared to lack the practical skills that would usually be evident in this paper.

Q1 (a) This was well answered by most candidates although a few did not use the table correctly and put the T value below y, making it difficult to read. These candidates sometimes did not repeat. The main error was recording T to 3 d.p.

(b) This discriminated well, weaker candidates did not calculate a 'k' value and this led to vague, incorrect statements without justification.

Q2 (a) Part (i) was well answered by most candidates although several had answers that were below 300 g for the first reading suggesting they had not followed the correct procedure. In Part (ii) the most common error was failing to convert the mass to kg.

(b) Some candidates did not repeat and average. The surface area calculation was generally well done.

(c) This was well answered by most candidates. Some went back to the 2 values of force and gave themselves extra work rather than using their answer to Part (a)(ii).

Q3 (a) & (b) Were well answered by most candidates. A few did not quote the values to the expected d.p.'s or were inconsistent.

(c) There were a significant number of power errors where mA had not been converted. Some candidates calculated an average. Very few divided by 2 to calculate the internal resistance of each cell.

Q4 (a) & (b) These were well answered by most candidates. A few did not quote the values to the expected d.p.'s or were inconsistent.

(c) Very few candidates gave the correct reason here. Most concentrated on the uncertainty in measuring u and v values. Few mentioned percentage uncertainty.

Assessment Unit AS 3B Practical Techniques and Data Analysis

Overview

This component was an optional component in 2022 and only a few centres opted to complete this component. The standard of responses across these centres was generally good and most candidates were well prepared for the examinations. Although some appeared to lack the practical skills that would usually be evident in this paper.

Q1 **(a)** This was well done by most candidates. A few reversed the axes. Scales and labels were generally correct, candidates seemed well prepared for the graph. The best fit line proved difficult for some.

(b) Candidates found this difficult. Few scored three marks. Most candidates scored one mark for showing an attempt to calculate the area. Many incurred a 10^n error.

Q2 **(a)** The gradient was calculated correctly in most cases. Some candidates had difficulty giving a consistent unit and lost a mark here.

(b) Part (i) was well attempted by most candidates. The most common error was for candidates to use the equation and square the value of v2 leading to an incorrect answer. Part (ii) was done well by many but a number of candidates did not score the second mark here.

Q3 **(a)** The majority of candidates were able to record the correct values and units in Part (i). A surprisingly large number read the value from the newton-meter incorrectly. In Part (ii) the uncertainty for measurements of length and mass did not cause much difficulty but many candidates did not record the correct uncertainty in T.

(b) This question discriminated well between candidates. Many did not get a correct value for f as they failed to read the stem of the question carefully and did not realise that the 3.91 g was the mass per unit length of the string. Candidates who did correctly use the value of 3.91 g then often forgot to convert the value to kg. The % uncertainties in L, T and μ were correctly calculated by many candidates but few halved the % uncertainties in T and μ to determine the % uncertainty in f. The absolute uncertainty in f was generally calculated correctly from their % uncertainty. Few gave the answer to the correct number of significant figures.

Q4 **(a)** Most candidates were awarded the mark for an acceptable best fit line.

(b) The majority of candidates correctly calculated the difference in temperature but some used the temperature at L=0.7 m rather than 0.6 m.

(c) This was well done by many candidates. The extreme fit was usually drawn although some went on to use gradient rather than the difference in temperatures, giving themselves extra work. A few used only the error in the temperature value for L=0 m to calculate the % uncertainty.

Q5 **(a)** This was well answered by most candidates. In Part (iii) some answers lacked detail and only achieved one of the marks available.

(b) This discriminated between candidates. Only top candidates were able to provide a concise, logical and sequential answer to explain how the mass of the metre ruler was obtained. It appeared that many candidates had perhaps not carried out the practical. Some stated the principle of moments without any experimental detail.

Assessment A2 1 — Deformation of Solids, Thermal Physics, Circular Motion, Oscillations and Atomic and Nuclear Physics

Overview

Overall, the paper had excellent specification coverage and sufficient range of questions to test pupils of all abilities. The standard of answers was generally good but there was a very wide range of final marks scored by candidates. Disappointingly, for some A2 Level candidates, they were unable to perform some mathematical operations on their calculator, deal with prefixes, rounding and significant figures. It was also noticeable that quite a few candidates struggled to successfully recall definitions.

There were also some very high quality answers and excellent levels of understanding of physics concepts, which was very reassuring. Questions 1(b)(ii), 2(a)(i), 2(a)(ii), 2(a)(iii), 4, 5(b)(i), 5(c) & 7(c) presented the most difficulties for all candidates.

Q1 (a) The definitions of angular velocity and frequency were generally well answered, however some candidates did mention “oscillations” instead of applying the theory to a rotating wheel.

(b) In Part (i) most candidates calculated the linear speed correctly. A significant number of candidates failed to calculate the radius of the wheel correctly in Part (ii). In Part (iii) it appeared that many candidates guessed the shapes of the graphs as their answers were not connected or related to known relationships.

Q2 (a) In Parts (i) and (ii) the spring constant was generally well calculated. However, quite a few candidates tried to apply the Hooke’s law equation to values of length in the table and average the results, leading to 0 marks scored. Another common error was forgetting to convert the mass into a weight. In Part (iii) candidates often failed to convert units for extension and spring constant correctly to enable the energy to be calculated in Joules. Another common mistake was to confuse strain with energy. Other candidates did not read the question carefully and used the wrong mass values from the table. Other common mistakes were to forget the ½ in the strain energy equation or forget to square the x when using $E = ½kx^2$. In Part (iv) the graph shape was well drawn and the point X above which Hooke’s Law was no longer obeyed was also identified by most. The mistake which was completed by the majority was failing to recognise the graph should not intercept the origin.

(b) This calculation was well practiced and executed by most candidates. A factor of 2 error was common here where candidates failed to correctly divide the stretching force by 2. Again, a power error was common where candidates did not recall Giga correctly. A few candidates worryingly thought that G was the Universal Gravitational constant.

Q3 **(a)** Candidates often drew more apparatus than was required in the question and then forgot to discuss the use of the apparatus in Part (b).

(b) The specific heat capacity of a liquid experiment was generally well answered. The most common errors were either omitting the apparatus from the description or ignoring the SHC of the container. While most scored highly, very few candidates scored full marks with even the very best descriptions failing to rearrange the equation to determine the SHC of the liquid.

Q4 **(a)** Part (i) was poorly answered by many candidates. Few were able to give a full description.

In Part (ii) a surprising number of candidates defined 1Bq as the 'number of disintegrations per second'.

(b) This question was not well answered with candidates attempting to calculate using a range of activity equations. The most common mistake was treating the value of background radiation over 5 mins, not 10 mins.

(c) Only the very best candidates knew to take the anti-log of 8.18 to get the actual activity. ECF helped the majority of candidates access some marks. Many candidates just used 8.13 as the initial activity or used ln 8.13. Some candidates unnecessarily converted both the decay constant and the time into seconds often introducing errors.

(ii) This calculation was also poorly executed. The use of the decay constant in day^{-1} was common.

Q5 **(a)** A surprising significant number of candidates couldn't explain what an electron volt was although the calculation to determine the equivalent energy value of I u was well done my most. It was noted though that candidates often ignored the instruction to quote their answer to 3 significant figures.

Part (iii) was usually well known by candidates with the majority scoring 1 or 2. The description in Part (iv) was very well answered by those who read the question and referred to the graph.

(v) The 38 was usually given, but often 143 rather than 144 for the mass number.

(b) Parts (i) and (ii) were very poorly done. Only a handful of candidates were able to score well in this part. Detail was lacking and answers were poorly constructed.

(c) This was again not well done. Detail was lacking and most candidates scored only one or two marks.

Q6 The damping graphs were generally well done. Some candidates incorrectly drew a sine curve for Part (i) and a few did not show two cycles within 2T. Most candidates showed a decreasing amplitude. Part (ii) and (iii) were also well drawn.

Q7 **(a)** The period of oscillation was correctly calculated by majority of candidates. Some candidates incorrectly approached the calculation using $T=2\pi\sqrt{(l/g)}$.

(b) An amplitude = 0.04 m was incorrectly used by a significant number of pupils. A surprising large number of candidates also incorrectly used the readings on the half metre stick as the amplitude.

(c) This was possibly the most challenging question on the paper with very few candidates achieving full marks. It differentiated well. Only the strongest candidates recognised the negative value of the displacement. Not all candidates remembered to use cos in radians.

Q8 Most candidates scored highly in Part (a) and (b) and particularly so in Part (c)(i), a good number also managed Part (c)(ii) where there was a high level of challenge.

(a) Boyle's law was correctly identified by most candidates although there was some confusion with the words inversely and indirectly. Part (ii) was well answered although quite a few candidates drew a separate graph below the question which could easily be missed during the online marking process.

(b) A common mistake was having temperature in degrees C not K and also not correctly calculating the pressures.

(ii) Generally well answered though there was some "mixing and matching" of Kinetic Theory equations. For example confusion between n (moles) and N (molecules). Those that started with pV=1/3Nm<c2> found it difficult to progress and usually scored 0.

Assessment Unit A2 2 Fields, Capacitors and Particle Physics

Overview

The paper had wide coverage of the specification including the required synoptic element which some candidates struggled with. There were parts of every question where most candidates could access some marks, but a lot of candidates did find this paper challenging. There was evidence of a lack of mathematical skills in calculations by weaker candidates. For stronger candidates their knowledge and skills were comparable to previous years.

Q1 **(a)** Most candidates scored 2 of the marks in Part (i) for the circular field and direction but very few clearly showed the increased spacing as distance from the wire increased. Part (ii) was answered well by most.

(b) This straightforward calculation was well answered although weaker candidates could not complete to get the correct answer.

Q2 **(a)** Most candidates scored at least some marks in this part with many excellent, well explained answers gaining full marks. Some stated that both plates needed to be positive to create an equal and opposite force and couldn't proceed from the incorrect physics.

(b) Top grade candidates had no difficulty with this unstructured calculation in Part (i) and were able to show clearly what they were doing. Others tried to use the equation for the electric field around a point charge. Most scored at least one mark for quoting E = V/d. Part (ii) was well answered by the minority. Most candidates did understand that the oil drop would fall to the positive plate but could not adequately explain why this would happen.

Q3 **(a)** The majority of candidates realised that the resultant force would be zero, but their explanations were usually vague without mentioning equal and opposite forces for the second mark.

(b) Part (i) was very well answered and Part (ii) was well answered by most candidates though weaker candidates could not complete the calculation. A common error was not using the correct distance between the charges.

Q4 (a) Kepler's third law was well learnt by many candidates but there were a significant number who were not able to quote it correctly.

(b) Part (i) of this question was not well answered by weaker candidates. They had difficulty with the ratio aspect and could not correctly complete the mathematics required if they tried an alternative method. Good candidates had no problem getting to the correct answer easily. Fewer candidates managed to get Part (ii) correct but again, the top grade candidates had no problem. Others missed the physics of the two g fields being equal in magnitude and just tried to put one equal to zero.

Q5 (a) The majority of candidates scored some marks in Part (i) but many missed the first marking point by not showing that the basis of the derivation was coming from two forces equations that were then equated. Part (ii) was well done by most candidates as expected from a straightforward calculation.

(b) This was well answered by the majority of candidates.

Q6 (a) As part of the 'show that' requirement here full working out was needed. The equations are given on the data sheet so a full substitution was required for the first mark. Some candidates missed out on this. There were a number of candidates who could not work out which of the capacitors were in parallel/ series.

(b) Both calculations in Part (i) and Part (ii) were straightforward and well completed by most candidates.

(c) Top grade candidates had no problem with the calculation in Part (i) although they did make a few power errors. Weaker candidates sometimes applied the capacitor equation to the resistors or simply added all the resistances together. Most did manage to get the marks for calculating current from an incorrect resistance. Some did not appear to recall the equation $R = V/I$. Part (ii) was quite well answered, some candidates had curves that touched both axes and others were asymptotic at both.

Q7 (a) This was not well answered by candidates. Many did get credit for a correct statement of Faraday's law and a few of the other available marks, mainly those about the effect of a greater force on the string. Very few made the link between the moving guitar string in the magnetic field leading to a magnetic field being produced around the string. When they missed this step, they then couldn't carry the explanation on further.

(b) Part (i) was well completed by many candidates, but others appeared not to know what a standing wave looked like. This could have been the result of lack of preparation by some for the synoptic element of the paper. The calculation in Part (ii) was the same, some candidates had no problem but others could not complete with many starting with speed = d/t and no mention of frequency or wavelength in relation to wave speed. Almost all candidates scored at least one mark in Part (iii) for the realisation that the frequency would decrease. Only some were able to adequately explain why this happened.

Q8 (a) This was well answered by many candidates although some tried to use Equation 8.1 even though they did not have values. A few left their answer in terms of π and were penalised. The unit was generally known among those candidates who got to the correct answer. There were very few candidates who gave the unit of ω without the correct value suggesting that those who did not calculate it from the graph perhaps were not clear what ω represented.

(b) This was well answered by most candidates.

(c) Most candidates scored one mark for realising that the amplitude would decrease over time. Fewer scored the second for the time period increasing.

Q9 (a) Part (i) was well completed by many candidates. A significant number included the unit of the gravitational constant for G. Part (ii) was well done by top grade candidates but weaker candidates struggled and often divided by c^2 twice.

(b) Part (i) was well answered by most candidates. Few candidates got two marks in Part (ii), often ticking three boxes rather than all four. In Part (iii) most got the idea of the opposite charge and difference in mass but didn't always get the mass difference the correct way round. Some thought that they had to have the same charge because they repelled each other and ignored the magnetic field aspect.

(c) In Part (i) the explanation of annihilation was generally well done although some mentioned release of gamma rays without the conversion of all of the mass or the idea that the particle and anti-particle disappeared. Part (ii) was quite well answered although commonly candidates were out by a factor of two and lost a mark.

Assessment Unit A2 3A Practical Techniques and Data Analysis

Overview

This component was an optional component in 2022 and only a few centres opted to complete this component. The standard of responses across these centres was high and the candidates were well prepared for the examinations. The most common mistake throughout the whole paper was not giving their answers to the correct number of significant figures.

Q1 (a) The vast majority of students were all able to get a good set of results in the experiment. Some candidates struggled giving the readings and averages to the correct number of significant figures.

(b) In Part (i) the values for h were correctly calculated by most candidates. Some candidates did not quote the numbers to the correct number of significant figures. Several candidates were not able to give the correct unit in the heading. The vast majority of candidates were able to draw the graph in Part (ii) correctly however a number of candidates failed to use a scale that allowed the data to take up more than half the page.

(c) In Part (i) most candidates correctly calculated the gradient, some candidates were not able to give the correct unit with their gradient. Almost all candidates gave a reading between 2 and 5 cm in Part (ii), a few candidates failed to give their answer to the correct number of significant figures. Several candidates struggled with Part (iii). Some used the 9.81m s^{-2} rather than the quoted value. While a number of candidates correctly calculated a value using their measurements it did not fall within the range given indicating inaccuracies in their experimental technique.

Q2 (a) The vast majority of candidates were able to get a good set of results. Some had very similar values for their first and second readings and may not have correctly followed the instructions.

(b) In Part (i) most candidates were able to correctly deduce that the value was the initial voltage across C_1. Part (ii) was answered well but a number of candidates failed to correctly map the equation to y = mx+c. In Part (iii) the majority of candidates were able to correctly calculate the values. Some did not correct place the units inside the brackets in the log. Weaker candidates did not quote their values to the 2 decimal places stated.

(c) The vast majority of candidates plotted the graph correctly even though the graph involved required both positive and negative values on the y-axis. Some candidates did not use an appropriate scale or realise a false axis were required.

(d) The vast majority of candidates were able to correctly calculate the gradient. A few candidates used too small a triangle and some candidates used points that did not lie on their line of best fit.

(e) Some candidates struggled to correctly determine Z from their gradient. Weaker candidates also struggled to rearrange Eq 2.2 to determine C_1. Any candidate who carried out the correct calculation tended to fall within the range given for the quality mark.

Assessment Unit A2 3B Practical Techniques and Data Analysis

Overview

This component was an optional component in 2022 and only a few centres opted to complete this component. The standard of responses across these centres was high and the candidates were well prepared for the examinations. The most common mistake throughout the whole paper was not giving their answers to the correct number of significant figures.

Q1 (a) The majority of candidates answer this question correctly. Some failed to extract the gradient from the equation of a straight line given. Some did not give the correct unit.

(b) In Part (i) several candidates drew a steeper line of best fit failing to deduce that a smaller gradient will give a larger age. Some attempts at extreme lines of fit did not correspond to the data and were not awarded the mark. Most candidates were able to calculate both the gradient and the age from their extreme fit line in Part (ii). Some candidates used too small a triangle or failed to read points correctly from their graph. A number of candidates struggled to include the powers of ten given as part of the units on the graph when doing their calculations.

Q2 (a) In Part (i) a significant number of candidates failed to identify that a microphone was required and name other common Physics equipment such as power supplies/voltmeter. In Part (ii) most students were able to calculate T correctly and identify the correct time base setting. A number of candidates failed to give the correct unit with their answer omitting the cm^{-1}. Part (iii) was answered correctly by the majority of candidates.

(b) Some candidates failed to measure across a number of waves in Part (i) and dropped a mark in accordance with the markscheme. In Part (ii) most candidates correctly calculated a value for f consistent with their previous answer. Some did not clearly show calculations of a range or a percentage to support their conclusion.

Q3 **(a)** This question was answered correctly by most candidates. In Part (ii) some omitted the negative and lost a mark accordingly.

(b) Part (i) was answered well with just a few candidates making rounding errors or not giving their values to the required 2 decimal places. Most candidates were able to plot the graph in Part (ii) and label their axis correctly. Several candidates were unable to scale the axis correctly, either going up in steps of 120s on the x-axis or not using a false axis on the y-axis. In Part (iii) most candidates were able to read the intercept in the required range, however some candidates were then unable calculate T_o which indicated a lack of ability to rearrange equations involving logs.

Q4 **(a)** Part (i) was answered correctly by most candidates. In Part (ii) candidates were able to recognize that the switch is needed to maintain a constant temperature but a lot of candidates failed to link this back to the experiment and its affect on resistivity. There was a widespread in the quality of responses to Part (iii). Some candidates gave excellent answers describing several procedures to gain an accurate reading with excellent use of scientific language. Several candidates stated ‘to repeat and average’ even though it was already stated in the question.

(b) Part (i) was correctly answered by the vast majority of candidates. In Part (ii) most candidates were able to state the correct absolute uncertainty although some candidates struggled to calculate the percentage uncertainty from these values. Most candidates were able to correctly calculate the resistivity in Part (iii) but some candidates failed to double the percentage uncertainty in the diameter when adding the individual percentage uncertainties. The majority of candidates were unable to answer Part (iv) correctly, while a number of the candidates did correctly calculate the absolute uncertainty, they failed to give their answer to 1 significant figure.

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