GCE EXAMINERS' REPORTS

GCE
PHYSICS
AS/Advanced

SUMMER 2022

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PHYSICS

General Certificate of Education

Summer 2022

Advanced Subsidiary/Advanced

AS UNIT 1 – MOTION, ENERGY AND MATTER

General Comments

Candidate responses were encouraging with many aspects of the paper scoring well. However, a few questions did not score as well as expected or were not attempted by an unusually high number of candidates. For example, assessment objective 1 style questions such as recall of definitions and other general recall questions did not score as highly as anticipated, such as the question testing candidates' knowledge of Newton's third law. Other examples included the definition of velocity and showing how the equation provided for accelerated motion could be obtained from the given velocity-time graph.

Contrary to this was the very encouraging response to the QER question testing candidates' knowledge of hadrons. Responses to the practical question were satisfactory, however many candidates failed to determine correctly the absolute uncertainty in the answer for Young modulus. Once again, calculating the cross-sectional area of a wire from a given diameter caused more problems than it should have. Likewise, many candidates lost marks for confusing surface area with cross-sectional area in questions testing stellar physics. Questions exploring experimental technique were also poorly answered as was the question testing candidates' ability to confirm an inverse square relationship from a graph. Whilst the general standard of literacy and numeracy was good, the overall standard of candidate presentation was disappointing, with examiners commenting on the difficulty of reading a significant number of poorly laid out responses.

Comments on individual questions/sections

Q.1 (a) The majority of candidates were able to state the conditions for a body to remain in equilibrium. A significant minority either left the question blank or gave 'nearly correct', yet uncreditworthy responses e.g. *no net momentum* was often seen.

(b) The majority of candidates were able to show the weight of the beam as required. Many of the successful answers were based on a 'net forces' approach, with some candidates taking a reverse approach to answering the question. That is, they started with the weight of the beam and added to it the weight of the coat. They showed that the total weight of beam and coat was shared evenly between the two supports. This is a perfectly valid approach. A few candidates attempted a moments-based approach which, although valid, involved more work which often led to mistakes.

(c) Nearly all candidates attempted to answer the question, but with varying success. The majority attempted to take moments about F_A and F_B, with few attempting moments about the centre of the rod. Common errors included forgetting to include the weight of the horizontal beam (introduced and calculated in (b)) or calculating the relevant distances incorrectly. A few candidates confused F_A with F_B.

Q.2 (a) (i) Most candidates were able to calculate the work done correctly. The most common error was to omit the factor, $\frac{1}{2}$, in their calculations.

(ii) Only a few candidates were able to give a clear and concise answer. Candidates could have referenced the formulae for energy in a stretched spring or the area under the graph to support their answers, but few did so.

(b) (i) Only a few candidates understood the energy concepts involved with the movement of the car along the track and loop. Many, for example, did not include the gain in GPE in their calculations. Some candidates did not make the link between the energy calculated in part (a) and this part. The majority assumed that the elastic potential energy was converted solely into kinetic energy and carried out calculations based on this incorrect assumption. 1 mark was awarded for solutions based on this approach.

(ii) In this part ecf was applied extensively. Many good attempts to calculate the mean resistive force were seen, with candidates picking up marks for determining the correct fraction of energy to use, the correct distance the car had travelled and for applying the correct force-energy relationship.

Q.3 (a) (i) Nearly all candidates were able to state Newton's third law of motion. Most did so by reference to 'action' and 'reaction', with fewer taking the 'body A and body B' approach. In both cases the omission of 'opposite' was a frequent reason for not awarding the mark.

(ii) By contrast, the application of N3 was poorly answered with few correct answers seen. Candidates should be encouraged to answer questions such as these through re-arranging the words in the sentences already provided. e.g 'Gravitational force of Earth on drone' (provided) should lead candidates to respond: 'Gravitational force of drone on Earth'.

(b) (i) Nearly all candidates were able to state the relationship between force and momentum, with many choosing to do so using the equation. A common error was to omit reference to 'change' in momentum or to omit reference to time, e.g. both force = momentum divided by time and force = change in momentum were often seen but could not be credited. Some candidates used phrases such as '**in a** period of time' which was not credited.

(ii) Most candidates were able to determine the weight of the drone correctly.

(iii) Few candidates gained full marks. Many errors were based on not calculating the net force correctly or using the weight of the drone rather than determining its mass.

(c) (i) A significant minority were unable to give a correct definition for velocity, with 'speed in a given direction' being a common incorrect response.

(ii) This part was well attempted. Nearly all candidates calculated the speed of the drone correctly. Fewer candidates determined the displacement correctly but were able to gain the mark for determining the velocity as ecf. In nearly all cases a correct conclusion was given which was consistent with their calculations for speed and velocity.

(d) Nearly all candidates were able to give one benefit and one risk for drone technology.

Q.4 (a) (i) As in previous questions of this nature, many candidates made errors in powers of 10 when converting from one base unit to another. In this case the conversion from mm to m was incorrectly carried out by a significant minority, leading to cross-sectional area (CSA) answers being incorrect by factors of 10. Most candidates were able to correctly determine the percentage uncertainty in the CSA, a few doing so via a maximum-minimum method.

(ii) Nearly all candidates were able to show that the % uncertainty in the length was approximately 0.05%, and thus negligible.

(b) (i) Only about half of the candidates were able to determine the Young modulus of the metal correctly. This was surprising as it was seen as a straightforward application of the Young modulus formula. A common error was to not convert the mass (1 kg) into weight which led to many answers being incorrect by an approximate factor of 10. Ecf was applied to incorrectly calculated CSAs from (a)(i).

(ii) Some good attempts were seen with many candidates picking up some credit for their responses. Some candidates omitted to calculate the % uncertainty in the extension and were penalised one mark. Ecf was applied in this case and most candidates who did omit the uncertainty in diameter achieved the mark for the overall % uncertainty. In many cases a further ecf was applied from their calculation of the Young modulus from (b)(i) and many candidates were able to determine a value for the absolute uncertainty in the Young modulus. Sadly, very few candidates gave this uncertainty to the correct number of significant figures as required and did not therefore gain the final mark.

(c) The mark for Jack's conclusion should have been accessible to all candidates. The mark for Karen's conclusion was awarded if the conclusion was consistent with the candidate answers to part (b).

(d) Those candidates who attempted answers often provided incomplete or irrelevant responses. For example, 'repeat the reading for extension' was often seen. Whilst taking many readings of extension for varying weights would have been a valid response, simply repeating a reading for the same weight (as implied by the above response) would not lead to greater accuracy. Many candidates did pick up one mark for 'repeat readings of diameter at various points and orientations.' Few candidates referred to the way that the results could be analysed by use of an appropriate graph.

Q.5 (a) Many candidates gave good and detailed accounts of hadrons. These included details of the two or three sub-groups with examples provided. The higher scoring responses included a quark analysis, including how the charge on stated baryons and mesons are determined from their individual quark make-up. A significant number of candidates referred to the dominant strong force in hadrons. Low scoring candidates tended to get mixed up between hadrons and leptons.

(b) The majority of candidates were able to use the conservation of charge, baryon number and lepton number to show that the given interaction was possible. In a minority of cases, a quark-based analysis was provided instead of the baryon analysis, which was credited.

Q.6 (a) Candidates either scored very well or very poorly here, reflecting their level of preparation. Those who scored well used the graph to give expressions for the area under the line and its gradient. They went on confidently to derive the given equation of motion. A minority of candidates had clearly learnt to derive the equation from a purely algebraic perspective, notwithstanding that, in many cases, their starting point of using the expression for mean velocity also represented the area of the trapezium given. Correct algebraic responses of this nature were awarded 2 marks.

(b) (i) Nearly all candidates were able to determine the vertical component of velocity correctly.

(ii) Far fewer candidates were able to calculate H correctly, with a significant number showing little understanding of how to approach the problem. A minority were able to apply the expression given at the beginning of the question confidently to the given situation, including being able to apply the correct signs in the relevant places. A minority of candidates broke the motion down to smaller sections, using the equations of motion correctly for each part to determine the height H.

(iii) Once again, the majority were able to determine the horizontal distance travelled.

(c) The majority of candidates gained some credit for making relevant statements related to the trajectory of the shot-put at an increased vertical angle. However, only the better candidates provided full and logical responses, which included a comment about the increased time of flight, the reduced horizontal velocity, and a reasonable conclusion.

Q.7 (a) The majority of candidates were able to explain the term *black body*. A common reason for not being able to award the mark would be for candidates who referred to 'light' only.

(b) (i) Very few candidates were able to show how the graph describes an inverse square relationship. Many did not attempt this question part, reinforcing the feeling amongst examiners that this skill is not well understood. Successful candidates usually approached the question by choosing pairs of values from the graph and multiplying intensity with $(\text{distance})^2$ for both pairs.

(ii) Many candidates were able to take a pair of values from the graph and, recalling the expression for luminosity, correctly determined the Sun's luminosity.

(c) Many candidates were able to calculate the radius of the sun successfully. Nearly all candidates gained the first two marks for determining the sun's temperature. Fewer candidates were able to apply Stefan's law successfully for the second two marks. In many cases, candidates used the area of a circle formula rather than the formula for the surface area of a sphere.

Summary of key points

Candidates would benefit from:

- Learning key definitions, such as the *conditions for a body to remain in equilibrium* and the term *black body*. Teachers should emphasise the need for careful wording when answering definition-based questions. Examples of commonly seen misuse of language which led to candidates losing marks include:
    - Velocity equals **rate** of change of displacement **over time**;
    - Velocity is the displacement **in a given** time;
    - Force is the momentum divided by time;
    - A black body absorbs all wavelengths;
    - If a body A exerts a force on body B then body B will exert an equal force on body A.
- Understanding the process of converting units from one power of 10 to another. Examples would be to calculate cross-sectional areas in m^2 given radius or diameter data in mm. This is a common difficulty seen in many papers in the past.
- Considering the validity of numerical answers to the real-life context being considered. Examples of clearly incorrect answers seen in this question paper were:
    - Velocity of drone = $2400\,m\,s^{-1}$
    - Cross sectional area of wire = $2.5 \times 10^8\ m^2$
    - Height of release of shot-put above ground = 23 m
    - Radius of sun = 7×10^2 m
- Ensuring that an appropriate unit is given for all calculation-based questions. On average two unit marks are considered in each paper. That is, two marks are deducted across the paper for incorrect or missing units even if the answer given is correct.
- Understanding how to confirm a given relationship using graphical (or other forms) of data. Q7(b)(i) is an example where this skill was required.

PHYSICS

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AS UNIT 2 – ELECTRICITY AND LIGHT

General Comments

Question 2, which included theory from conduction of electricity, resistance and DC circuits, provided the highest mean mark. The mean percentage mark for questions 5 and 8 was 50. These questions covered the nature and properties of waves and refraction of light respectively. By contrast, question 1, based on the specified emf practical, had the lowest mean mark. The QER question involving progressive waves covered sections 4(a) and 4(b) of the specification. These sections were generally well known although future emphasis on spelling, grammar and layout of responses will aid candidates in this type of question.

Comments on individual questions/sections

Q.1 (a) The majority of candidates gave partially correct answers here. Although many showed an understanding of an energy transfer to electrical energy, the minority made reference to either the 1.5 J or made reference to the unit charge.

(b) (i) A significant number of candidates failed to see the link between the equation given and $y = mx + c$. The most common response involved the realisation that the graph line was straight. We did not hold out for a negative gradient at this stage. References to the positive y intercept were less common. An understanding of $y = mx + c$ is fundamental to many experiments where a straight line can be drawn, and candidates who do not have an appreciation of this relationship will be at a disadvantage.

(ii) Attempted by nearly all candidates, the magnitude of the gradient was generally well calculated, however, the realisation that gradient was negative was too often not stated. This response also required a unit. Candidates should be encouraged to carefully consider the unit they provide for calculation-based questions. In each assessment unit, at least one mark is awarded for correct use of units.

(iii) This was reasonably well answered as candidates read 1.45 V from the graph and linked this to the emf of Anwen's cell. Some candidates tried to calculate the emf using the equation given. This was not always successful.

(c) (i) Relatively straight forward graph skills were tested here. Predictably this was very well answered.

(ii) The majority of candidates showed an appreciation of the relationship between resistance and current and correctly answered this question.

Q.2 (a) (i) Around half of the candidates knew that n was the number of electrons per unit volume. We held back the need for the 'free' electrons here. Electron density and electron concentration were also acceptable answers.

(ii) This standard derivation was well accessed by most candidates. A well labelled diagram helped candidates who were often able to access the first marking point. We were not looking for algebra alone. A good derivation showed a clear indication of what each line of algebra equated to.

(iii) This was well answered. Many candidates were able to rearrange and substitute values. Some candidates incorrectly used the diameter in their calculation and / or made errors with powers. These slips resulted in the loss of one mark.

(b) (i) Most were able to explain this in steps. Some answers were minimalistic and not always clear. The first marking point was less well accessed. Stating the pd is the same across both the 12 Ω and 24 Ω resistor was required, or at least, strongly implying they were aware of this. Some candidates accessed this by calculating 2.4 V across the 12 Ω and then using this across the 24 Ω. Clearly explained responses involving ratios were also credited, however, candidates did not regularly access the first marking point following this method.

(ii) This question proved very accessible for candidates. They were able to recall the resistance in series and parallel equations and use $V = IR$. Alternative responses involved an understanding of pd's across resistors in series.

(iii) Candidates found alternative routes to answer this question. As in the previous question part it was well answered. Some candidates did not always state the equation they were using which is important in a *show that* response.

Q.3 This was a fair QER question with a mean mark just below 50%. The nature of progressive waves proved to be the less well-known aspect. A minority of candidates discussed particle oscillations through the medium. Many referred to the wave 'transporting energy without matter'. The difference between longitudinal and transverse waves was generally well explained. A minority of candidates were unable to give examples of both types of waves. It is worth noting that water waves are not a good example of a transverse wave.

Q.4**.** (a) (i) The mean mark for this question part was 50%. The first marking point proved to be challenging for some as they were unable to correctly calculate Δy. Candidates should be encouraged to scan such diagrams and note where peaks or troughs align with the dashed vertical scale lines. Many candidates were able to use the double slit equation, but a small number did not consider units resulting in an incorrect final answer.

(ii) This proved to be more challenging. Some were able to link the intensity drop to diffraction. Few candidates realised that the diffraction for each slit, with width greater than the wavelength, resulted in diffraction not spreading round through 180°. For those that did, some used a diagram to aid their response.

(iii) In I, many candidates were able to state that the wavelength of infra-red light is greater than visible. The second mark was accessible to many, although those using the double slit equation and stating Δy increases did not always reference a and D being constant. In II, based on the diagram given, we did not accept reference to the laser being moved. We were specifically looking for an increase in D or a decrease in a. A small number of candidates seem to have confused slit separation with slit width and were unable to gain credit.

(b) This 'issues' based question tested candidates' understanding of how the science community would confirm Young's conclusion. Most candidates stated the conclusion from the experiment was that light was a wave. A minority incorrectly believed that the conclusion was light was both a wave and a particle. The suggestions regarding *repetition of the same experiment* and *completion of other experiments* were regularly seen, however, there were only a minority of full mark responses.

Q.5 (a) (i) The calculation of wave speed proved challenging to more candidates than anticipated. The wavelength was stated in mm and the time axis given in milliseconds. The latter was missed by a significant number of candidates. Candidates are advised to carefully consider the multiplier that precedes the unit of measurement.

(ii) In I most candidates were able to correctly draw the displacement-time graph for the wave produced by the single source and the resultant of both sources. In part II we were looking for the candidates to show an appreciation of an identical graph line followed by a graph line with twice the amplitude. Good practice was demonstrated by candidates who marked points on the grid before attempting their line.

(iii) Some candidates found this challenging as they were unable to see the link between the path difference and the wavelength of 20 mm marked on the diagram. Those who identified a half wavelength path difference often went on to mention the phase, but not always the correct phase. 'Antiphase' and 'exactly out of phase' are examples that were awarded credit. Mentioning that the displacements cancel or simply stating destructive interference was enough for the final mark.

(b) (i) The substitution and manipulation into the diffraction grating equation saw many candidates scoring well in this question part. A significant number of candidates demonstrated a lack of understanding regarding 'beam order' and hence did not use $n = 3$ in the equation. They were unable to gain any credit here.

(ii) Deemed as a more demanding question by candidates, simply stating 3λ or calculating its value were enough for the mark here. A minority of candidates rather inventively used the right-angled triangle along with d and a suitable angle to calculate the length x. They were awarded credit for this.

Q.6 (a) The explanations of the *work function of rubidium* were generally good. Unfortunately, a minority of responses didn't include reference to an electron.

(b) It is worth noting that the question asks the candidate to 'explain in terms of photons'. A minority of candidates accessed the first marking point where they needed to show that they understood that an electron is ejected by a single photon. They do not co-operate. More candidates were able to state that the photon supplies energy ϕ. The third mark was for stating that the photon energy is hf and reference to the inequality, namely $hf_{\text{min}} = \phi$ or $hf > \phi$ or $hf \geq \phi$.

(c) (i) The calculation of mean V from a set of six readings was generally excellent. Some candidates may need reminding that the resolution of the instrument is used as the absolute uncertainty for a single measurement. In the case of this question, where repeat readings have been recorded, $\frac{V_{\text{max}} - V_{\text{min}}}{2}$ is used to find the absolute uncertainty.

(ii) There were many paths for candidates to tackle this question. Responses from candidates produced a full range of marks. Some candidate showed knowledge of $E_{\text{k max}} = eV_s$ in their calculations. Many candidates could apply the Einstein equation to calculate either ϕ or $E_{\text{k max}}$ depending on their evaluative approach. Candidates picked up 2 marks if they were able to do this. The final mark was gained by candidates who appreciated that the absolute uncertainty calculated in (i) allowed for a range of values for ϕ or $E_{\text{k max}}$.

Q.7 (a) (i) Although this was well answered by the majority of candidates, a significant number of candidates could not state that there were more electrons in level U than L, even though in the stem of the question they were informed that the lasing transition was between these levels.

(ii) The majority of candidates were able to add the pumping arrow as well as the drops from P to U and L to G to complete the standard transition diagram for a 4-level laser.

(iii) This 'explain' question required a reference to a greater probability / more likely / more chance of stimulated emission for the first marking point. A good number were able to access this. Candidates too often failed to relate this to absorption for the second mark. The final mark, which required reference to the extra photon and hence amplification, was correctly answered by fewer candidates.

(b) There were some candidates who did not attempt a calculation. Those that did, generally realised the 1.20 eV given in the diagram needed to be used in some way. Converting eV into J correctly allowed for the first marking point.

Many candidates were able to use $E = hf$ or $E = \frac{hc}{\lambda}$ and calculated the frequency or wavelength of infra-red radiation. Candidates were specifically asked to give their reasoning in this question. The third marking point was more demanding. The candidate needed to show an appreciation of the lasing transition being less than 1.20 eV. The frequency being less than their calculated value or the wavelength being greater than their calculated value was stated by only a minority of candidates.

Q.8 (a) (i) In this question we were looking for more than ‘it spreads out’ or ‘it goes in different directions’ for the first mark. ‘Different distances / routes / paths’ were regularly seen responses and were awarded credit. This second marking point appeared more difficult as ‘different times’ was not regularly referenced.

(ii) This is a question where the minority of candidates had learned the necessary physics. The monomode fibre having a ‘thinner core’ or ‘light only taking one path’ were seen by some candidates.

(b) (i) $n_1 \sin C = n_2 \sin 90$ or equivalent was used correctly by many candidates. A small proportion of these candidates gave a final answer of 80° not realising that there was one more step to make.

(ii) Candidates are reminded that some basic geometry skills are required in this topic. A greater angle to the axis results in a *core-cladding striking angle* which is less than critical. Candidates who appreciated this generally realised that TIR would not occur, hence, refraction at the boundary and light leaving the core into the cladding.

Summary of key points

- An understanding of $y = mx + c$ is fundamental to experiments 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 carefully consider the unit they provide for calculation-based questions. In each assessment unit, usually two marks is awarded for correct use of units.
- Future emphasis on the layout of responses will aid candidates in *show that* questions. Candidates are also encouraged to state any equations they are using in this type of response.
- Some candidates may need reminding that the resolution of the instrument is used as the absolute uncertainty for a single measurement. Where repeat readings have been recorded, $\frac{\text{max value - min value}}{2}$ is used to find the absolute uncertainty.

PHYSICS

General Certificate of Education

Summer 2022

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 was of the right level of difficulty and provided good differentiation for the cohort of applicants.

Topics: The weakest topic this year, as in most years, was the comprehension. The topic was deliberately chosen to be less synoptic in nature but this did not seem to help the candidates overall. With a mean mark of 40%, this was the only question with a mean mark below 60%. Comparing the internal energy of an ideal gas and a liquid also proved problematic.

Language: Answers to the QER were of a high standard this year but the explanations in the comprehension were less successful.

Mathematics: Question 5(e)(i) was surprisingly poorly answered. This is a standard skill in unit 5 and is usually very well done. However, the $\propto \frac{1}{r^n}$ caused problems.
Other than this, 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". For many candidates, they should set out their work more neatly in algebraic derivations e.g. 2(b)(i) and 4(c).

Practical skills: Uncertainties provided some difficulties again this year especially in 5(d) where the uncertainty in a logarithm was required. As soon as candidates realised that they could obtain the answer by first principles they scored well.

Comments on individual questions/sections

SECTION A

Q.1 (a) (i) Very few problems with the unit but there was a large minority that could not define activity.

(ii) Generally very well answered. Most candidates scored 3/3 but some candidates were stuck when having to take logs or did not convert the half-life to a decay constant.

(iii) The mean mark was slightly higher than 2/3 so very well answered. Sometimes candidates omitted to state that alpha particles are highly ionising or failed to mention a specific problem caused by ionising radiation.

(b) Again, well answered. The step that caused most problems was obtaining the final speed of the alpha particle. It is rather strange that the radium atom will originally have 88 electrons and so the radon atom is also expected to have 88 electrons. However, the alpha particle has no electrons. This means that the radon has 2 electrons too many while the helium (alpha) has 2 electrons too few. Overall, the masses of the “missing” or “extra” electrons can be ignored and the mass of the electron is not required. This is a subtle point and the mark scheme was generous towards ±2 electrons.

Q.2 (a) (i) Very well answered.

(ii) Nearly all candidates could come up with a valid method but only a minority could obtain the correct answer. Nearly all mistakes were related to using an incorrect mass.

(b) (i) Very well answered and candidates were able to derive the expression by many and varied methods. As one might expect, some of these derivations were difficult to follow.

(ii)&(iii) Very well answered.

(c) (i) Few candidates scored many marks here with the mean mark being below 1/3. Few candidates stated that the internal energy of an ideal gas is KE. Fewer candidates stated that the internal energy of a liquid was both PE and KE.

(ii) Well answered but a minority wrote strange answers e.g. -273 K or 0 ^{o}C.

Q.3 (a) (i) Candidates were told in bold print to identify **two** characteristics **of the graph**. So most of them did not! Negative gradient and zero intercept were the magic words.

(ii) Very well answered but this was expected given that it was a “show that”.

(iii) I&II&III Well answered in general although the unit of the spring constant was often omitted and some candidates were unable to calculate the maximum speed.

(iv) Also well answered but one cycle caused most of the dropped marks. Few candidates realised that there would be two maxima of KE.

(b) Well answered in general. Most candidates were able to explain resonance and damping and were able to give good examples. Unfortunately, it was less common to see all 3 aspects of the explanations from individual candidates.

Q.4 (a) Well answered in general but a surprising number of candidates failed to say that it was a measure of angle.

(b) Very well answered although the conversion from 105 minutes went awry sometimes.

(c) Very well answered too although some responses were very difficult to follow.

(d) With a mean mark of 2/3, this was well answered. The most common omission was forgetting to subtract the radius of the Earth at the end.

(e) This part question caused more problems as one would expect and the mean mark dropped below 50%. Coming up with a strategy is the important step with these types of question. The most successful strategy on this occasion was calculating the radius of the orbit with a period of 105 minutes and then concluding that this was inside the surface of the Moon (and hence impossible).

Q.5 (a) (i) Very well answered although the mark scheme was slightly generous. It was decided that we would not insist on blocking alpha particles because there was a minimum 40 cm gap between the source and detector. This meant that "to block beta particles" was good enough to obtain the mark on this occasion.

(ii) Well answered with nearly all candidates realising that this was to do with background radiation. Fewer candidates were able to explain the benefit of measuring the background before and after the experiment.

(b) Extremely well answered.

(c) (i) Very well answered.

(ii) Very well answered.

(iii) Here, the mark scheme was strict and few candidates scored this mark. Most candidates explained why it was impossible to plot the distance error bars but nearly all omitted to state that the count error bars could be plotted.

(d) This required the candidates to calculate $\ln 119 - \ln 103$ or $\frac{(\ln 119 - \ln 87)}{2}$ but most were unable to use this first principles approach. A few candidates noticed that $\frac{16}{103} = 0.155$ but none were able to explain why this is, in fact, the correct answer.

$$\frac{\mathrm{d}}{\mathrm{d}x}(\ln x) = \frac{1}{x} \qquad \text{hence we can approximate} \qquad \Delta \ln x = \frac{\Delta x}{x}$$

(e) (i) Two things caused difficulty here. First, not many candidates added a constant of proportionality. Second, taking logs of $\frac{1}{r^n}$ went wrong at times.

(ii) This tough final question was well answered but it was rare to find an answer where both gradients had been calculated correctly. It was very common to award 3/4 marks because one of the gradients was incorrect but everything else perfect.

SECTION B

Q.6 (a) Very well answered.

(b) Poorly answered. Not many candidates stated that no work was done in steps 2 and 4 and very few stated that the work done in 1 was greater than the work "done on" in 3.

(c) A tough area calculation but quite well answered. It was rare to encounter a good approximation of the area. Surprisingly, most good approximations were done by counting squares on this occasion.

(d) A surprising majority did not realise that this was related to heat flow through the metal cylinder to the surroundings.

(e) A tough explanation and very poorly answered. Most candidates did not realise that cooling on expansion is explained using the First Law of Thermodynamics and many were attempting (unsuccessfully) to use $pV = nRT$. Candidates who realised that the internal energy decreased were quite rare and those who realised that the PE of the molecules actually increased were very rare.

(f) This easier question was well answered.

(g) Too many candidates were quoting Newton's third law rather than applying it to this context – if only they were able to identify body A and body B. Very few answers mentioned "moment" to link the motion to a rotation.

(h) This was quite well answered with most candidates being able to talk about sound but fewer able to explain the origin of the sound. Using the words "displacement" or pressure would have helped.

(i) Most candidates did not realise that this was about suffocation and would insist that the container would explode even though there was a "loose lid to let out nitrogen gas without pressure build up".

Summary of key points

- When two characteristics of a straight line graph are required, it is reasonable to assume that these are the gradient and intercept.
- Candidates should be able to compare the internal energies of ideal gases and liquids.
- Cooling via expansion is explained using the First Law of Thermodynamics – the volume increases hence work is done; there is no time for heat to flow; the internal energy of the gas decreases; hence the KE of particles and temperature decreases (this is simpler than the version in the comprehension that also incorporated an increased PE of the particles).
- Calculating uncertainties by using first principles is useful when logarithms are involved.

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A2 UNIT 4 – FIELDS AND OPTIONS

General Comments

Adaptations were in place for this paper, which meant that the options questions were not assessed in summer 2022. The general standard of performance of candidates is to be commended. The statistics indicate that the paper was of an appropriate level of difficulty and provided good differentiation for the cohort of applicants.

Topics: The weakest topic this year was electric fields along with some aspects of binary stars.

Language: Answers to the 6 mark QER were not of a high standard this year and candidates found it difficult to discuss similarities and differences between electric and gravitational fields.

Mathematics: No particular mathematical weaknesses were apparent this year.

Comments on individual questions/sections

Q.1 (a) (i) Well answered generally but many candidates forgot to divide the number of turns by the length and some forgot to make a conclusion.

(ii) Only 43% of the cohort knew that an iron core was the answer.

(b) (i) Responses here were disappointing. Perhaps the problem lies in the fact that two equations have to be used: $\Phi = AB\cos\theta$ and flux linkage $= N\Phi$.

(ii) After tackling flux linkage in part (b)(i) candidates were fixated with flux linkage here too and not the rate of change (or cutting) of flux linkage. This meant that the most common mark was 0/2.

Q.2 (a) Very well answered although a small minority had field lines going into the positron or out of the anti-neutron.

(b) Not well answered in general and the mean mark was quite low. It seems that this was an unexpected question and that candidates struggled to compare the two fields. Note that candidates could gain a middle band answer just for stating: Electric fields can go into or out of charges whereas gravitational fields always go into masses. They both obey the inverse square law.

Q.3 (a) Candidates usually did better if they drew vectors for the forces rather than the fields. Candidates who got the field arrows correct were not usually able to explain that the force was in the opposite direction because the electron is negative.

(b) Candidates who could resolve the vectors horizontally usually obtained full marks. Unfortunately, most candidates were not able to obtain the resultant field (or force).

(c) Most candidates only calculated one potential energy (for half marks).

(d) This was a difficult question and resulted in the second lowest percentage mean mark. In light of responses to part (c), it is not surprising that the vast majority failed to explain this using potential energy. Force explanations were slightly more successful with a large number of candidates realising that the negative charge would always repel. Only a small minority of candidates realised that the forces from the positive charges were equal and opposite for point P and point R.

Q.4 (a) Very well answered.

(b) (i) Well answered although a minority could not juggle the relevant equations. A very small minority insisted on using $U = \frac{1}{2}QV$ and substituted the capacitance as the charge.

(ii) Very well answered but some obtained the wrong arrangement and others did not use the symbols for capacitors.

(c) (i) Well answered in general but there were some strange answers here too.

(ii) There were many, many ways of answering this question but it was not well answered in general.

(iii) This was well answered and algebra was usually clear.

(iv) All that was required was comparing the equation with $W = Fd$ but the majority did not see this.

Q.5 (a) (i) Not well answered in general. When candidates knew how to approach this part of the syllabus, the algebra was clear. The most disappointing part of these proofs was that candidates could not explain the initial scenario e.g. stating that we are considering a galaxy (or anything) and seeing if it has enough KE to escape the gravitational field of the Universe.

(ii) Well answered. Candidates were very competent at obtaining the critical density. The mass of 5 hydrogen atoms caused more problems.

(b) (i) Almost universally correctly answered.

(ii) Very well answered. The most common mistake was using the wrong value for d.

(iii) Quite well answered although a minority did not know how to obtain the orbital speed ($v = \frac{2\pi R}{T}$ is the easiest method).

(c) Poorly answered and this resulted in the lowest mean percentage mark.

(d) (i) Well answered in general.

(ii) Poorly answered but this factor of 5 was difficult to arrive at. Not many candidates could see that the black hole being 2× closer would exert 4× the force.

(iii) Not well answered in general. Most candidates failed to see that $F = \frac{mv^2}{r}$ was the relevant equation.

(e) Most candidates realised that experimental evidence would be required. Few stated that this evidence should be in agreement with the theory for the theory to be accepted.

Q.6 (a) (i) Not particularly well answered. The mark that was awarded least often was the correct direction of the force on the electrons.

(ii) Not particularly well answered. Those who wrote $Eq = Bqv$ and $E = \frac{V}{d}$ invariably obtained full marks.

(iii) A common mistake here was not being able to convert 7.26×10^{-5} m s^{-1} to mm s^{-1}. This was also true for converting 6.55×10^{-8} V to nV. This led to some incorrect conclusions.

(iv) Correct substitution into $I = nAve$ is the main problem here and it is the area which causes the most mistakes.

(b) Quite well answered considering that candidates had to convert m^{-3} to cm^{-3} in their heads.

Summary of key points

- Induced emf does not depend on the flux linkage itself. It depends on the rate of change (or cutting) of it.

- Vector addition of fields is not to the standard that it used to be. Addition of potentials or potential energies is not as strong as in previous years.

- In the derivation of the critical density of the universe, the situation should be set up first before going straight into algebra. Simply stating “consider the escape velocity of a galaxy / mass from the universe” would suffice.

PHYSICS

General Certificate of Education

Summer 2022

Advanced Subsidiary/Advanced

A2 UNIT 5 – PRACTICAL EXAMINATION

General Comments

The experimental task and the practical analysis task were generally well answered. In the experimental task, candidates produced good results which were clearly presented in a single table along with clear, well drawn graphs.

In the practical analysis task, the maths skills shown by the candidates were good with the majority being able to manipulate equations as well as being able to determine the gradient of a graph.

Comments on individual questions/sections

EXPERIMENTAL TASK

(a) (i) The vast majority had been well taught to handle log conversions with the majority using natural logs ($\ln$) and able to compare with $y = mx + c$ so obtaining the first two marks. Unfortunately, very few provided trial readings, a number of candidates referred to them but failed to produce any and so lost the third mark. The sample size (minimum of 5 readings over a 40 cm range) along with the need for repeat readings needed to be stated in the method and was not marked from the table. Many candidates mentioned reducing parallax / reading at eye level for the final mark. This was also awarded by using a clear well labelled diagram.

(ii) Well answered and teacher assessed.

(b) Tables were well drawn with clear units and titles. A few still insist on putting units on log values but this was only penalised once (in the table and ecf applied for the graph). It was pleasing to see that significant figures were consistent for every column, including log values, throughout the table.

(c) (i) The graphs were generally well drawn with all points plotted correctly. In a few cases inappropriate scales were chosen with candidates using less than half of the graph paper available to plot their points.

(ii) Triangles / points were clearly identified for the first mark. Some candidates failed to mention that the gradient = n and so lost the second mark. The gradient was generally correct, we allowed a large margin of uncertainty as it was a dynamic practical and also ignored units and significant figures.

(iii) A point needed to be taken from the graph and not the table. It really helped when the point used was identified on the graph, either by using dashed lines or by circling it. Identifying that $c = \ln k$ and then proceeding to calculate k was generally well done.

(d) The majority of candidates mentioned using cameras / freeze frame photography (light gates were not accepted as they would need to be continually adjusted). A number mentioned using a partner / release mechanism which was acceptable, however more repeat readings / better resolution was not accepted.

PRACTICAL ANALYSIS TASK

Q.1 The majority of candidates were able to determine a value for the energy stored in the spring. Also, the uncertainty in the extension was also determined correctly by nearly all candidates. However, when combining the uncertainties to determine the overall uncertainty in the energy; the factor of 2 was omitted for the uncertainty in the extension due to the square factor in the original equation. Candidates were then able to gain credit for the final conclusion if this factor had been omitted or that they had obtained an incorrect value of energy.

Q.2 The analysis was based on a nominated practical in that candidates were asked to determine the magnetic flux density from data on the force on a wire in a magnetic field.

(a) The table was completed well. A small number of candidates lost the third mark by incorrectly determining the uncertainty in the force.

(b) The graph was generally very well done. Good choices for the scale were made and very few plotting errors were seen. The maximum and minimum lines were well drawn with many candidates using rectangles to signify the error bars.

(c) (i) This part was more discriminating with only the more able candidates able to provide the marking points in their answers. Many candidates did not refer to the fact that the line passed through the error bars in their answers.

(ii) This was well answered, triangles / points on the graph were clearly indicated and gradients calculated correctly. There were no unit or significant figure penalties in this part.

(iii) The mean gradient was calculated correctly in the majority of cases (ecf was sometimes applied) but unfortunately a number of candidates quoted the % uncertainty to too many significant figures.

(d) (i) Many candidates identified that the gradient equalled Bl and calculated the field B = 0.12 T with correct units. However, some candidates decided to use data from the table rather than using the mean gradient from the previous part and, their final answer was quoted without regard to using appropriate significant figures.

(ii) This part was not answered well. Candidates were expected to refer to an instrument used in the practical and to refer to the resolution in their answers. Frequently candidates referred to more repeat readings or changing the apparatus in its entirety.

Summary of key points

In the experimental task, candidates must plan to take trial run results **and** record them in their plan.

In the practical analysis task, skills that require further development are in relation to evaluating and analysis, especially when using uncertainties and data from the graph in question 2.

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