GCE EXAMINERS' REPORTS

GCE (NEW)
PHYSICS
AS/Advanced

SUMMER 2018

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PHYSICS

General Certificate of Education (New)

Summer 2018

Advanced Subsidiary/Advanced

UNIT 1

General Comments.

The general response was encouraging with candidates showing a good understanding of the topic areas covered in the paper. The mean mark for AS candidates was 52.8, that is 66.0%

The mathematical demands on the candidates did not seem to cause too many problems, with good skills being shown in handling equations and adding vectors. Examiners did comment however on the lack of understanding evident from some candidates when converting or using units (Q 3(b)). Many candidates also confused surface area with cross-sectional area (Q 6(b)).

Markers also commented on the generally poor standard of literacy. Marks were often not awarded because of a lack of clarity, poorly reasoned extended responses or contradictory statements. In many cases, long, 'rambling' sentences could not be interpreted and were not credited. It should be noted that 'benefit of doubt' cannot be awarded where precision and lack of clarity is missing.

Questions involving experimental analysis, particles, momentum and stellar Physics were generally well attempted. Candidates' knowledge of basic definitions was disappointing however. Many, for example, lost marks for not knowing standard definitions for the moment of a force or the principle of conservation of momentum. In contrast, it was encouraging to note that the majority of candidates displayed good understanding of the microscopic structure of rubber and the blackbody graph and associated absorption spectrum.

Specific comments.

Question 1

(a) Only a minority of candidates succeeded in providing a valid equation for the moment of a force about a pivot. In many cases the term' perpendicular' was missing from definitions, in others the term 'mass' was used instead of force.

(b) (i) The majority of candidates correctly calculated the clockwise moment produced by the weight of the window.

(ii) Fewer candidates were able to calculate the force, F, in the metal bar. The use of incorrect distances was the cause of many unsuccessful attempts.

(c) Few candidates were able to provide clear, concise and correct answers to this question. Candidates were required to make reference to the increased distance from the window to the pivot (C of G reference not required) in position 1, which then leads to an increased clockwise moment, hence an increased anti-clockwise moment and therefore an increase in F (Bethan correct). An equivalent response based on position 2 was acceptable. Many answers lacked a logical line of reasoning.

Question 2

(a) (i) Nearly all candidates calculated the resultant vertical force correctly. The majority of candidates proceeded to successfully calculate the resultant velocity and a relevant direction of travel. Many candidates lost the final mark for not showing or labelling the direction of travel.

(ii) Stating that the force of gravity = air resistance was not enough to be awarded the mark. Candidates also had to qualify this remark with a follow up statement such as 'hence no acceleration', or 'hence no net force (acts on the hailstone)'.

(b) (i) Many candidates understood that the systematic error should be subtracted from readings. It was apparent however that a significant minority of candidates had little understanding of the concept of systematic errors and provided incorrect responses based on the treatment of absolute uncertainties.

(ii) Nearly all candidates calculated values of t^2 to the correct number of significant figures.

(iii) Most candidates gained at least 1 mark here for stating the appropriate equation of motion. Fewer candidates were able to apply this to the context given in the question; that is to state that '$u = 0$' and '$a = g$', and hence did not clearly show how the relationship given in the question was obtained from their equation of motion.

(iv) The majority of candidates were successful in gaining full marks for drawing the graph. In some cases however, marks were lost for incorrect labelling of axes or for not extending the line of best fit back to (or near to) the origin.

(v) This question required candidates to *use the graph* to determine a value for g. In many cases, it was obvious that candidates used values from the table and the equation given to determine g. This approach was not credited. It was expected that some evidence of the use of the graph was seen by examiners, either through an appropriately drawn triangle (with $h \geq 1.0$m), or specific points shown on the graph. The mark scheme allowed for gradients between 4.6 and 5.0.

(vi) Few candidates picked up all of the marks on offer here. Many candidates did make correct reference to the line being 'straight' or to the fact that the value of g obtained from their graph was close to the accepted value (ecf was applied here if the candidate value was not close to g). Few candidates made reference to the fact that the line of best fit went through (or close to) the origin.

Question 3

(a) The majority of candidates gained 2 marks (from 3) for an acceptable diagram (or description), and for a brief description of the experimental process. Few candidates described how the extension of the rubber could be determined accurately, in terms of taking an initial reading of length, a second reading following the addition of a load to the rubber, and then subtracting reading 1 from reading 2.

(b) (i) Nearly all candidates were able to determine the strain in the rubber correctly.

(ii) Few candidates were successful in gaining full marks for determining the Young Modulus of the rubber. In the majority of cases, candidates, attempting to change the value of the given area from cm^2 to m^2, did so incorrectly. Candidates, who did treat the given information correctly, often gave the incorrect unit for their Young Modulus value. Answers in N cm^{-2}, N m^{-2} or Pa were acceptable.

(c) Good responses were seen by many candidates who were able to describe correctly, on a molecular level, the reasons behind the changing gradient of the graph. The majority of candidates who lost marks did so because they did not clearly make the link between their molecular description and the graph gradient.

Question 4

(a) Most candidates were able to give correct answers and values for the quark combination, charge and baryon number for the given particles. Nearly all candidates correctly identified the electron as being the lepton.

(b) The majority of candidates provided clear and concise responses showing how charge and lepton number are conserved in the given interaction.

(c) (i) Fewer candidates gave clear and concise responses showing how both 'up' and 'down' quarks were conserved in the given interaction. In many cases, the following response was seen, with no further explanation:

$$\mathrm{uuu} \rightarrow \mathrm{uud} + \mathrm{u}\bar{\mathrm{d}}$$

1 mark was awarded for this. Candidates who proceeded to state that $\mathrm{d}\bar{\mathrm{d}}$ would annihilate (or equivalent) were awarded the second mark.

(ii) The majority of candidates were able to give at least one valid reason for believing that the decay was a strong force interaction. Common responses included reference to the conservation of quark flavour and the fact that no neutrinos were present in the decay.

(d) Few candidates appreciated the link being made by the spokesman between the discovery of particles which, at the time of their discovery, had few uses, and the subsequent significant uses for the electron and proton. Many did not appreciate that, at the time of their discovery, the electron and the proton had no discernible uses, but that subsequently, items such as TVs, computers etc. were invented as a consequence of their discovery. Candidates were not expected to name specific devices, but it was disappointing to note that many candidates seemed unaware of the impact the electron and the proton have had on society.

Question 5

(a) Nearly all candidates were able to identify Newtons 2^{nd} law.

(b) (i) This is the first time that determining the gradient using a suitable tangent has been tested in this series of exams. It was encouraging to note that the majority of candidates responded well with well-drawn tangents drawn at the correct point and of suitable length. Tangents of less than 1.0 s 'in length' were not credited. The majority of candidates who drew appropriate tangents were successful in determining the resulting force on the spacecraft.

(ii) Nearly all candidates used ΣF = ma correctly to determine the mass of the spacecraft.

(iii) Nearly all candidates correctly identified a point on the graph where the resultant force on the spacecraft = 0.

(c) (i) Disappointingly, a significant number of candidates were unable to provide full and correct statements of the principle of conservation of momentum. In many cases, reference to either the net (or total, sum of etc) momenta were omitted or no reference was made to external forces. It was noted by examiners that greater use was made of 'closed systems' as an alternative to 'external forces' than in previous years, which was accepted.

(ii) The majority of candidates understood that the initial momentum could be obtained from the graph. Unfortunately, many omitted the 10^3 factor given on the vertical axis. Nearly all candidates gained the second (independent) mark for giving a correct expression for the momentum following collision. Some candidates were awarded the final mark as ecf following an incorrect reading from the graph.

Question 6

(a) The majority of candidates made good attempts at the QER question, making reference to both the graph and the spectra provided. Nearly all candidates stated that the graph provides information about the colour of the star. A significant number also stated that the star's temperature could be found in conjunction with Wien's law. Fewer candidates proceeded to mention the inverse square law, Stefan's law and the subsequent information which could be gained about the distance and size of a star. With regard to the spectra, again many candidates named the type of spectra and discussed its origin, but fewer proceeded to state that the spectra indicated the elements present in the star. It was noted by examiners that a significant number of candidates provided 'long-winded' answers which failed to get to the point. Consequently many candidates seemed to run out of space and did not continue with their answers on separate sheets. It should be noted that about 5-6 clear points needed to have been made in order to access the higher band on the marking scheme.

(b) (i) The majority of candidates were able to recall the inverse square law and apply it correctly to the situation given. Most candidates gained full marks here.

(ii) The majority of candidates were successful in applying Stefan's law correctly to determine Altair's surface area. However, far fewer candidates proceeded to determine the diameter correctly. In many cases it was apparent that candidates assumed they had calculated the cross-sectional area as opposed to the surface area of the star, equating their area to πr^2 instead of $4\pi r^2$.

Question 7

(a) (i) The majority of candidates applied work = power $\times$ time correctly to show that the work done by the motor was approximately 2 MJ. However, a significant minority used the equation incorrectly, **dividing** the power by time which, owing to the values given in the question, also gave an answer approximating 2 MJ. No credit was given for incorrect use of the equation.

(ii) Nearly all of the candidates who calculated the gravitational potential energy at B correctly also went on to calculate the efficiency of the mechanism correctly. A degree of tolerance was allowed for the final answer, ranging from 51% to 55%.

(b) Only a few candidates were successful in gaining all 5 marks on offer. The majority succeeded in gaining some of the marks available. In many cases, candidates did not take into account the resistive forces acting on the carriages. Other candidates considered the whole drop (42 m) rather than the drop from B to C (30 m).

PHYSICS

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Advanced Subsidiary/Advanced

UNIT 2

The mean mark for AS candidates was 49.0, that is 61.2%

In general the electricity questions scored rather better than those on the other topics. Questions on the newest material in the AS specification – photon momentum and the derivation of the diffraction grating equation – were usually not answered well. The photoelectric effect was a weakish area this time. Perhaps surprisingly, explaining why light of frequency less than $\frac{\phi}{h}$ cannot eject electrons from a surface of work function ϕ, though surely 'book-work', caused almost as much difficulty as the rather challenging identification problem.

Question 1

(a) (i) Most candidates began the paper well, by giving acceptable definitions of emf.

(ii) Most of the successful determinations of the cell's internal resistance started with a calculation of the current. In this step, quite a common mistake was to divide the emf, rather than the terminal pd, by the external resistance.

(iii) I Asking for a qualitative explanation of why the terminal pd would fall if the external resistance were lowered was known to be testing. A minority of students correctly argued that the increased current would result in a greater voltage drop ("lost volts") across the internal resistance, leaving a smaller pd across the terminals. It is not valid to concentrate on the external resistor and to argue from $V = IR$ that a smaller R implies a smaller V – unless proper account is taken of the increase in I.

II Most candidates knew that to find the number of electrons entering one of the resistors per minute they had to multiply the current by 60 s and divide it by e. Often the sum of currents in the two resistors was taken (one mark penalty). Occasionally the power was used instead of the current.

(b) Almost everyone could calculate the element's resistance from the power and the pd and most went on successfully to calculate the energy in MJ dissipated in an hour.

(c) Most candidates correctly saw the higher total carbon dioxide emission due to electric heating as the major issue, giving its climate change implications. 'Damage to the environment' and other vague answers did not receive as much credit. At least one counter-argument, such as not all electrical energy being generated in gas-fired power stations, was expected – and usually given.

Question 2

(a) Most candidates handled the potential divider well, and correctly deduced the temperature. Inevitably some confused total resistance and thermistor resistance.

(b) A fully argued answer (about linearity of response to temperature changes) would have been a tall order, but any reference to the graph's not being straight (or to changes in output pd not being proportional to changes in R_θ) was given full credit.

(c) Many candidates realised that the current needed to be low to avoid significant self-heating of the thermistor. Remarks about the *circuit's* becoming hot received 1 mark.

Question 3

(a) (i) The wavelength emitted by stimulated emission was usually calculated correctly from the energy level diagram – despite the units being eV.

(ii) We were not always told (for the first mark) that a population inversion was needed for stimulated emission events *to be more probable than absorption events*. Most students gained the second mark for stating that, in stimulated emission, one photon gives rise to two, or equivalent.

(b) (i) Most (but not all) candidates knew that they needed to divide the light power by the photon energy in order to determine the number of photons leaving the laser per second. Powers of 10 sometimes went adrift.

(ii) Many candidates successfully calculated the momentum of a photon, but a surprising number gave this as their answer to the question, rather than multiplying it by their answer to *(b)*(i), to obtain the momentum of the light leaving the laser per second.

(iii) As the surface was perfectly reflecting the rate of change of momentum of the light was twice the answer to *(b)*(ii). Many candidates correctly gave this as the (magnitude of) the force exerted on the wall.

Question 4

(a) Most candidates extracted λ = 0.24 m from the wave profile, and went on to deduce that T = 0.60 s. Displacement-time graphs were usually drawn as sine curves, missing the last mark for phase because, although at point P the displacement is zero at t = 0, the wave profile shows that a 'trough' is approaching P at time t = 0, so the displacement–time graph is an *upside down* sine curve.

(b) (i) Almost everyone used the grating equation competently to determine a wavelength from the first order angle.

(ii) *Explaining in terms of path difference* why the second order beams emerged at 57.4° was another story. We were testing the specified "*derivation* and use of $d\sin\theta = n\lambda$". The appropriate right angled triangle needed to be added to the diagram, and the path difference of 2λ identified as one side of it, and equated, by basic trigonometry, to $d\sin\theta$. Many candidates picked up the odd mark, but few showed real understanding.

Question 5

(a) (i) The spreading of waves through 180° shows that the wavelength is greater than or equal to the gap width. There was quite a common misconception that the wavelength needed to be roughly *equal* to the gap width.

(ii) Many candidates correctly pointed out that widening the gap will (at some stage) reduce the intensity of the waves diffracted through large angles. The intensity of waves diffracted through small angles would increase.

(b) Most of candidates calculated the path lengths S_1P and S_2P correctly with the help of Pythagoras' theorem. Few used these path lengths, as asked, to calculate the wavelength. All that was needed was to double the path *difference* (14 mm), as the minimum at P was the first minimum out from the central (zero path difference) maximum. Attempts to use the Young's slits formula (not really applicable) usually contained bad errors.

Question 6

(a) (i) The mean value of the distance *x* was almost always calculated correctly, and its percentage uncertainty, not quite so often.

(ii) Using $v_s = 4fx$ to find the speed of sound gave little difficulty, and most candidates knew that to find the absolute uncertainty in v_s they first needed to add percentage uncertainties in *f* and *x*. Various arithmetical errors were often made. We accepted values of (335 ± 8) m s^{-1}, or, with less enthusiasm, (334.8 ± 8.4) m s^{-1}.

(b) (i) Many, but by no means all, candidates pointed out that $x = \dfrac{\lambda}{4}$ for this (fundamental) mode, and went on to gain the easy mark for substituting $\lambda = 4x$ into $v = f\lambda$.

(ii) Only a minority were able to show the positions of nodes and antinodes in the longer air column. Many students did not realise that there would still be a node at the bottom end (the water surface) and an antinode at the open end. Of those who did, many did not show an intervening node and antinode in roughly the correct positions. Sometimes too many nodes and antinodes were shown. Interpretation of candidates' diagrams was not an issue; we accepted N and A or · and ↕ or 'loops'.

Question 7

(a) (i) The straightforward Snell's law calculation was done well, but sometimes the refracted ray was drawn incorrectly (staying on the same side of the normal as the incident ray).

(ii) Most candidates realised that, for the case described, θ in the diagram was the critical angle, θ_C, and went on to calculate it correctly (though, in fact, only $\sin\theta_C$ was needed). The last mark was often lost, as many candidates did not see from the diagram that $x = 100\ \text{mm} \times \sin\theta_C$.

(b) To explain how a multimode fibre transmits light, we needed to be told about total internal refraction at the interface between core and cladding. Usually we were, but not without a few confused references to refraction, and some omissions of 'total'. [TIR is vital for light to travel any worthwhile distance.] As to the limitations of multimode fibres for data transmission, most candidates wisely began by explaining how light travelling at different angles (within the TIR catchment) would take slightly different times to travel a given length of fibre. Some – noting the last phrase in the question – pointed out that the discrepancy in times is greater the longer the fibre. How this affects data transmission was usually the weakest part of an answer. Students needed to state that the data was sent as a succession of light pulses. *A common mistake was to imply that different pulses take different routes along the fibre*. In fact each pulse travels by many routes and therefore arrives at the end of the fibre spread out in time. This could cause overlapping, even overtaking, of pulses if these are sent out as a rapid sequence. 'Interference' is a word best avoided at A-level in the context of multimode fibres, though it didn't attract a penalty unless the user had clearly misunderstood the Physics.

Question 8

(a) (i) Disappointingly, many candidates did not give us a clear statement that a photon with less energy than ϕ cannot eject an electron from the metal (or equivalent). This also put the second mark, for applying $E = hf$, in jeopardy. Most candidates gained a mark for explaining why increasing the light intensity didn't help.

(ii) Most students started by calculating the photon energy, but fewer immediately eliminated calcium and zinc, for which $\phi > hf$. All the same, many candidates did make more progress and there were some excellent answers. Perhaps the most straightforward method, though not the most elegant, was to calculate $hf - \phi$ for caesium, potassium and barium, revealing that the $E_{\mathrm{k\,max}}$ for barium was the only one that gave a stopping voltage in the right range.

(b) (i) Lines of best fit were usually well chosen.

(ii) Most candidates commented that a straight line seemed to fit the results, as the equation demanded. Rather fewer pointed out that the line *didn't* go through the origin, and therefore didn't support the equation.

(iii) Almost everyone knew the basic method of determining a gradient, though some candidates based their calculations on sections of the line that were too short, and, inevitably, some didn't factor in the 10^{14} on the frequency scale. Most students recognised from the equation that gradient $= \dfrac{h}{e}$ and went on to calculate h correctly (ecf given on gradient), but some divided instead of multiplying the gradient by *e*.

PHYSICS

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UNIT 3

The general standard of performance of candidates is to be commended. The mean mark was 82.7. The statistics indicate that the paper was perhaps a little too accessible but nonetheless provided good differentiation for the cohort of applicants. There was some evidence of a minority of candidates struggling with time restrictions towards the end of the comprehension section.

General Points

Topics. There were few signs of weakness in any of the topics this year except perhaps 3(b)(i) where setting up a soluble equation proved difficult for some. The data analysis question Q6 was very well answered and seemed a strength for the vast majority of the candidature.

Language The questions requiring explanations were answered well this year e.g. 1(a)(i), 2(b), 4(b) and 5(b). The golden rule of using short sentences still applies but few candidates lost marks due to linguistic skills.

Maths. Few problems with algebra were encountered again this year but algebra must be laid out neatly for "show that" questions e.g. 2(c).

Show that. Candidates now realise that extra proof is required and they invariably provide more significant figures than are given in the question.

Evaluation Some good answers e.g. 6(d)(iii) but some of the comprehension questions were challenging 8(e), (f), (g).

Prac skills A definite strength this year - Q6.

Detailed comments

Question 1

(a) (i) Well answered but some candidates insisted on answering using forces which was more difficult - **resultant** force provided by **friction** acting on the wheels was necessary.

(ii) Well answered but the straightforward conversion from km/h to m s^{-1} proved problematic for many.

(iii) Very well answered (often through error carried forward in spite of silly numbers being involved). Some candidates forgot to mention the direction of the acceleration and a very small minority were completely oblivious to the true direction of the centripetal acceleration.

(b) Many excellent answers but a surprising number of blank responses.

Question 2

(a) Very well answered generally but a tiny minority stated the wrong mass e.g. total mass. A significant minority thought that $\overline{c^2}$ was the rms speed.

(b) Very well answered.

(c) Although good marks were obtained by most candidates, answers were generally untidy, ill thought-out and poorly explained. This type of response to a "show that" is an area ripe for improvement.

d) The quickest way of obtaining the correct answer was using $U = \frac{3}{2}pV$ or, even better, $\Delta U = \frac{3}{2}p\Delta V$. Unfortunately, a large number of candidates simply calculated $W = p\Delta V$, for which no credit could be given. Unfortunately, many candidates wrongly assumed that the amount was 1 mol, presumably following on from part (c),

Question 3

(a) Well defined although there was a small minority of interesting wrong answers, the most common of which was defining the molar heat capacity.

(b) (i) As discussed above, setting up a soluble equation was the problem here. It could be done in many ways e.g.
From: equating energy lost by boiling water = energy gained by cold water.

$$16\times 4200\times\left(100-\theta\right) = 0.6\times 4200\times\left(\theta - 19.5\right)$$

or by considering the total ΔU above, say, 0 °C, often expressed as:
total thermal energy before = thermal energy after
giving: $1.6\times 4200\times 100 + 0.6\times 4200\times 19.5 = 2.2\times 4200\times\theta$
This latter method was often employed successfully with temperatures in kelvin

(ii) Although an easy question, many candidates received no marks here because they did not have an answer to the previous part. **In such cases they should just make up an answer for part (b)(i) e.g. 30°C and just carry on as normal.** Very few candidates used their initiative in this way and lost all 3 marks.

(iii) Very well answered although there were some convoluted wrong answers involving the First Law of Thermodynamics.

Question 4

(a) Almost universally correct.

(b) Generally well answered but there were many poor explanations of fusion and fission. The words molecules, atoms, elements and particles were being used regularly instead of nuclei in describing these nuclear reactions.

Question 5

(a) Very well answered although a small minority were stuck after obtaining the decay constant or the number of half lives. Another small minority obtained 11.2% as a final answer but needed (100.0 - 11.2)%.

(b) Surprisingly well answered - candidates are consistently mentioning **significant** and **further** drops. Most candidates realised that the background count was around 23-27 counts per minute which was excellent.

Question 6

(a) (i) Well answered but a minority of candidates did not realise that $F = kx = mg$. A smaller minority started from $2\pi\sqrt{\frac{l}{g}} = 2\pi\sqrt{\frac{m}{k}}$ which gives the same answer if you say that the length of the (non-existent) pendulum is the extension.

(ii) Very well answered.

(b) Very well answered but some candidates did not provide a conclusion. Other candidates calculated the fractional change in the amplitude which should be a constant because of the exponential nature of the decay.

(c) (i) Only a small minority could not state that $e^0 = 1$.

(ii) Although tricky, this was very well done. Only a very small minority could not take logs and rearrange correctly.

(d) (i) Almost universally correct - only a few rounding incorrectly.

(ii) Almost universally correct, just a few slightly incorrectly plotted points and unlabelled axes.

(iii) Most realised that this simply needed “straight line through origin” but some candidates gave over-complicated answers.

(iv) Excellent answers in the main - only a small minority making slips in their gradients or not realising that the answer was the reciprocal of the gradient.

(v) Very well answered and justified but a significant minority insisted that the single data point provided the better result.

Question 7

(a) (i) Very well answered but there were some strange correct answers by incorrect methods e.g. employing the circular motion equation $m\omega^2 r = mg$

(ii) Nearly always correct but a minority insisted on substituting a time into $v = \omega A \sin \omega t$, which resulted in wrong answers.

(iii) Surprisingly well answered even by those who obtained the incorrect answer to part (a)(ii).

(iv) Generally badly answered - the phase of the velocity was invariably wrong, the KE was often negative and nearly always the wrong shape.

(v) Usually poorly answered. Energy conservation analysis invariably resulted in the correct answer. Many candidates obtained correct answers using trigonometry but this proved less successful in general.

(b) Almost invariably correct. If there was a weakness, it could be said that the curves could have been drawn slightly more carefully.

Question 8 (Section B)

(a) This was well understood but answers were often worded poorly e.g. “pressure pushes the water out and then gravity acts on it.”

(b) Almost universally correct.

(c) Quite tricky. Many students could mention or realised that there was a maximum exit angle but few could explain or state rotational symmetry about the central axis (alternative, simpler wording was acceptable).

(d) Well answered but the most difficult step proved to be the first step of obtaining the angle of incidence i.e. 90^o - 80^o = 10^o (or 90^o - 78.8^o = 11.2^o).

(e) A difficult question based on the bandwidth-distance product for a multimode fibre. Most students were able to obtain a mark or two but it was rare to encounter a student who realised that multimode dispersion increases linearly with distance.

(f) It was pleasing to see that nearly all the cohort obtained 16 dB by multiplying the loss of 0.8 dB/km by the 20 km. It was perhaps surprising then to see so many candidates make an incorrect comparison with the 15 dB in the table on p19.

(g) One would have expected more students to know that the wavelength of e-m radiation is decreased by a factor of n in a medium of refractive index n.

PHYSICS

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UNIT 4

The general standard of performance of candidates is to be commended. This was a difficult paper but the mean mark was a commendable 80.3. The statistics indicate that the paper was of the right level of difficulty and provided good differentiation for the cohort of applicants. There was little evidence of candidates struggling with time restrictions this year.

General Points

Language Many of the questions requiring explanations were answered quite well this year e.g. 2(a)(i), 3(a), 3(d) and 5(d). The golden rule of using short sentences still applies but few candidates lost marks due to linguistic skills. Most marks were lost in 4(d) (the 6 mark QER) by not answering all that was required in the question e.g. candidates would explain how the motion of galaxies provides evidence for dark matter but not how the data had been gathered.

Mathematics Few problems with algebra were encountered again this year but algebra must be laid out neatly for “show that” questions.

Show that Candidates now realise that extra proof is required and they invariably provide more significant figures than are given in the question. However, the last substitution step before the final answer is sometimes missing and can be penalised. Many answers to these questions are incomplete e.g. 1(a)(iii)

Evaluation Many instances of good answers e.g. 2(b)(ii), 4(c)(i), 5(c). Perhaps the poorest answers were those to 4(c)(i).

Prac skills Some basic skills still need practice e.g. obtaining the uncertainty in a gradient from a steepest and least steep line. Also, the subtleties of the notation (*quantity* ± *uncertainty*) *unit* along with appropriate sig figs is still a problem.

Detailed comments

Section A

Question 1

(a) (i) Well answered. This is an equation that the cohort understands and applies with confidence.

(ii) Well answered generally but a small minority confuses the parallel and series rules for capacitors.

(iii) This is a classic example of incomplete explanations in a “show that” question. Nonetheless, candidates were reticent to state that the 2nF capacitors shared equally the charge on the 4nF side of the circuit. Candidates were far less likely to explain that the 4nF and 6nF parts of the circuit held equal (and full) charge (other methods also lacked complete explanations).

(iv) A surprisingly large minority obtained incorrect answers by using pds or charges that were inappropriate for the capacitances.

(b) (i) Well answered in general but a minority provided a discharging circuit rather than a charging circuit.

(ii) A well-differentiating question with all marks (0-5) being awarded regularly. Only the best candidates were able to score all 5 marks.

Question 2

(a) (i) Nearly all candidates recognised that KE and PE were involved and most realised that the increase in PE = decrease in KE (or equivalent). However, it was quite rare to encounter an answer where the candidate stated that KE (or PE) would be zero at infinity.

(ii) Generally very well answered but to be expected given the clue in part (a)(i).

(i) Rather bimodal in response to this synoptic question. Either candidates did well because they understood and remembered the existence of $\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT$ on the equation sheet or they scored nothing because they did not.

(ii) Well answered in general but explanations were often incomplete.

(iii) Generally approached well even though it is quite a tough evaluation question.

(iv) This caused a few problems. The most difficult step was dividing the mass of the Sun by the mass of hydrogen (or similar). Unfortunately, it was quite common to see the mass of the Sun divided by the electronic mass.

Question 3

(a) This new part of the syllabus seems to have come as a surprise to many candidates. It was rare to encounter a complete answer, with the most common omission being stating that the relative velocities of galaxies is assumed to have been a constant.

(b) Well answered and the surprise unit of the megaparsec seems to have caused no problems.

(c) Well attempted but it was rare to encounter a reply that merited full marks. The steps that proved problematic were combining the speeds (or shifts) to obtain the rotational and recessional speeds.

(d) It is crucial to read the question carefully when there are six marks at stake. Many candidates responded to “how spiral galaxies provide evidence for dark matter” but did not respond to “how this evidence has been gathered”.

Question 4

(a) Responses to this question were slightly disappointing considering that it has been a standard part of data analysis for over a decade. Most problems were caused by slight inaccuracies in reading the graph scales or slips. However, a common mistake was to quote the uncertainty as (max - min) rather than (max - min)/2.

(b) This question was answered well except for the last tricky mark. Remember that 1 or 2 sf in the absolute uncertainty are acceptable but that the sf in the final value must match. These are some typical mistakes:

3789.23±379: too many sfs in the uncertainty, far too many in the final value and the final least significant numbers in each do not match. Note that no unit was required this year because “number of turns” appears in the question and, in any case, “turn” is inessential.

3789.23±379 being rounded to 3800±380: This satisfies all conditions except that the least significant numbers in the value and error do not match (100s in the value, 10s in the error). Either 3800±400 or 3790±380 would have been acceptable.

(c) (i) Again, responses were slightly disappointing for such a standard evaluation of data question. Marks were awarded for

1 The value of *N* being inaccurate or inconsistent with that of the manufacturer.
2 Graph is a straight line.
3 The lines straddle the origin (best fit passing through the origin was credited).
4 The lines pass through all error bars.

(ii) The reason for disagreement was quite well answered but suggestions for improvement less so. Some typical responses were:

“More repeat readings” - useless because the variation is not due to random effects, nor are they anomalous. Repeat measurements are of no use when you have a systematic error.
“Hall probe not aligned properly” but no suggestion as to what to do to improve this.

Question 5

(a) (i) Well answered in general but candidates had the advantage of knowing the answer as it was a *show that* question.

(ii) Stating the rule used was fine but the direction of the current was often incorrect. Some answers were ambiguous e.g. to the left and could be given no credit. Other rare answers were bizarre e.g. out of paper.

(b) Surprisingly well answered for a tricky synoptic question but, again, candidates had the advantage of knowing the answer (show that).

(c) Reassuringly well answered for another tough synoptic question - it was common to award all 5 marks. However, there were many bad examples of the misuse of the equation $Q = mc\Delta\theta$ where candidates had taken Q to be the charge.

(d) The responses were pleasantly good.

Section B – options

Question 6 (Alternating current)

(a) (i) Well answered in general but some candidates were unsure of what to write.

(ii) This was an unexpected question for many candidates and many responses were poor, in spite of this being a requirement of the specification:
" ... the use of an oscilloscope (CRO or PC-based via USB or sound card) to measure: ac and dc voltages and currents; frequencies."
The most common mistake was to use the oscilloscope settings as the actual maximum pd and period i.e. plotting a peak pd of 5 V and a period of 2 ms.

(b) (i) Quite well answered but the idea of a maximum current was often missing.

(ii) Well answered but there were a few rare calculator errors. Even rarer were candidates who could not obtain the correct equation.

(iii) Most candidates knew exactly what to do and obtained full marks. However, calculator slips and power of ten slips were often encountered. A small minority did not employ a valid method.

(iv) Quite well answered but a small minority did not even calculate the Q-value(s) even though the hint was given in the question. Many candidates were stuck after calculating the Q-value(s) but they should have realised that all they had to do was multiply the supply voltage by the Q-value to obtain the pd across the capacitor.

Question 7 (Medical Physics)

(a) (i) This was not particularly well answered especially when drawing the spectrum. Many candidates omitted the line spectrum and some started the continuous spectrum at (0,0). A number made no attempt to calculate the wavelength.

(ii) This was generally well answered by the majority of candidates. A small minority calculated 0.7% of the power emitted as heat so getting 63 W rather than calculating 99.3%, these candidates only scored 1 out of 2 marks.

(iii) Many candidates struggled with the maths involved in this question and, particularly dealing with logs and exponentials. This was a bit surprising as similar equations and so mathematical techniques are used in radioactive and capacitor decay.

(b) (i) This was generally well done. A few candidates just wrote down the Doppler shift formula and so didn't gain any marks. Some correctly stated that the wavelength / frequency was shifted but didn't state that it had been reflected off blood / blood cells and so only gained 1 out of 2 marks

(ii) This was well answered by the majority of candidates. However, a significant minority confused the symbol c in the Doppler equation with the speed of light in a vacuum and so obtained some very strange values.

(c) (i) Generally very well done with the vast majority of candidates stating that a short half life was needed and that it should be a gamma emitter. Where a mark was lost was usually for not stating that it should be low ionising

(ii) This again was generally well done, although a few candidates did confuse the gamma camera with a PET scanner and described positron / electron annihilation.

(iii) This was not intended to be an easy question and it did prove to be discriminating. Some candidates tried using $E = \frac{hc}{\lambda}$ and were unable to access any of the marks. Some converted the electron's mass to amu. and then multiplied by 931 to get an answer in MeV – for full credit. Marking was done generously when candidates, at times rather randomly, cancelled out factors of two.

Question 8 (The Physics of Sports)

(a) The definition of angular acceleration was well understood and given correctly by nearly all the candidates.

(b) (i) The calculation of the torque on the gymnast was answered well by all candidates.

(ii) Nearly all candidates were able to gain some marks but only the more able candidates were able to provide a coherent and logical answer based on the conservation of angular momentum and the reduction of the moment of inertia.

(iii) Nearly all candidates were able to determine the force but did not use Newton's 3rd law to reason that the force exerted by the gymnast on the mat is approximately 1000 N.

(c) (i) This was not answered well with few candidates able to explain correctly in terms of the centre of gravity.

(ii) All candidates were able to gain some marks on this part. Frequently candidates did use the vertical forces to explain that the gymnast is in equilibrium with no resultant forces in addition to the fact that the net moment is zero.

Question 9 (Energy)

(a) (i) Most candidates were able to show the power output. Some did not name the law they were using. On occasion, the factor of 4 was omitted when calculating the surface area of a sphere.

(ii) Most candidates were able to balance the equation and identify the symbol. A small number of candidates did not appreciate that it was a 'net' equation which resulted in other particles incorrectly being added into the space provided. A small number of candidates incorrectly identified the particle as an electron.

(iii) This was found to be more demanding because some candidates were unable to convert eV into J correctly. Those that were successful with the conversion correctly determined the mean rate.

(b) Many candidates were able to use $I = \frac{P}{A}$ effectively in some form and make the '50%' comment. A small number of candidates found this difficult to access.

(c) (i) Generally, candidates were attempting to identify max power at the 'knee' and go onto determine the requirement. There were some issues with the reading of graph scales. Some candidates were calculating a power value but at incorrect points on the graph.

(ii) This was generally well attempted by candidates with a whole number of panels being regularly stated. However, only a few candidates made a clear connection back to the 750 W. Comments on changing conditions were also sometimes vague.

(d) (i) This was found to be more demanding. The detailed link between KE and T was not regularly seen. The electrostatic repulsion mark was most commonly accessed by candidates. There were only limited comments on the strong force.

(ii) The majority of candidates attempted to calculate the triple product. Some candidates were unable to calculate n correctly. Those that did showed a good use of units in arriving at the final answer. A small number of candidates were incorrectly attempting to use other equations from the data book.

PHYSICS

General Certificate of Education (New)

Summer 2018

Advanced Subsidiary/Advanced

UNIT 5

Experimental Task

General Comments

All candidates were able to gain marks on every part and as a consequence were able to demonstrate at least some knowledge of the practical skills learnt during the course. Nearly all the candidates were able to express the power relationship $P = kV^n$ as a log relationship and were then able to take appropriate results and plot an appropriate graph to determine n and k. However only the more able candidates were able to write a detailed method in part (a) and so gain full marks. Part (g) proved to be discriminating.

Nearly all teachers recorded the assessed marks as required on the cover of the scripts. However a very small number of centres had not recorded the marks.

Specific comments

(a) Nearly all candidates were able to draw a correct circuit diagram and also connect the circuit properly. Frequently the candidates were not able to give appropriate ranges and intervals as well as indicating how the pd or current was varied across the circuit. A small number of candidates had used an approach based on the current in that $P = kV^n$ can be written in terms of current as $I = kV^{(n-1)}$, for full credit. Nearly all candidates were able to deduce the correct log-log relationship to plot the graph.

(b) The table of results recorded by all the candidates was well done with many candidates gaining full marks.

(c) The graph was drawn correctly with many candidates gaining full marks.

(d) The candidates were able to determine n and k correctly from their graph.

(e) The expression for the power was given correctly by all the candidates.

(f) This part proved to be the most discriminating. Only a few candidates were able to gain full marks and explain clearly the changes to the values of n and k when the lamps are connected in parallel.

Practical analysis task

General comments

Question 1 was generally not as well answered as expected with many candidates just stating yes or no without giving any scientific reasons for their answers. Question 2 was generally answered better with the graph, part (b), in particular being well done. The paper proved to be more discriminating than in previous years. Many candidates struggled with part (d)i particularly with the use of units.

Candidates appear to have experienced no difficulty in completing the paper in the time available.

Specific Comments
Question 1

(a) A number of candidates assumed the drop height and rebound height were directly proportional because of the difference between them rather than calculating a constant of proportionality.

(b) Common mistakes were stating that more repeat readings / increasing the range or a higher resolution metre ruler would increase the accuracy rather than using slow motion cameras.

Question 2

(a) The table was generally well executed, in particular the first two columns. A common mistake was giving the uncertainly in the depression of the 3.0 N load as 0.0 rather than using the resolution of the ruler, 0.1 cm

(b) The graph was generally very well done which was encouraging as the lines of best fit in particular were not easy to draw.

(c) (i) This was well done with the majority of candidates being well schooled in drawing triangles / highlighting data points and calculating gradients

(ii) Mean gradient and its percentage uncertainty were generally well calculated, but the percentage uncertainty was often given to more than 2 significant figures and so that mark was not awarded.

(d) (i) Some candidates took a random point from the table to calculate the Young modulus rather than using their gradient and so lost a mark. The percentage uncertainties in the length, breadth and thickness, however, were well answered. Many candidates had difficulty in using consistent units and so were often many factors of ten out in their calculation of E, this was only penalised one mark. The final value in the absolute uncertainty of the Young modulus was sometimes given to more than 2 significant figures and unfortunately candidates lost that mark.

(ii) Many realised that the thickness of the ruler caused the greatest uncertainty but a number were unable to describe how this could be reduced

(iii) The majority of candidates realised that it was the weight of the ruler itself that prevented the graph from passing through the origin.

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