GCE A LEVEL EXAMINERS' REPORTS

PHYSICS
A LEVEL

SUMMER 2019

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PHYSICS

GCE A LEVEL

Summer 2019

COMPONENT 1 – NEWTONIAN PHYSICS

General Comments

The mean mark was an impressive 67.6 %. The highest mean marks were for question 1 (on projectile motion) and question 3 (about momentum). Answers to the extended response question, 7(b)(ii) were generally a little disappointing. Admittedly the question was quite a searching test of ability to use the first law of thermodynamics. The last question (comprehension) must surely have given candidates a sense of pride in what their A-level Physics equips them to understand. Detailed comments follow.

Comments on individual questions/sections

Q.1 **(a)** **(i)** Most candidates achieved both marks for stating that the only *horizontal* force on the stone was air resistance, which would be small. Several times, though, zero or small horizontal *acceleration* was offered as the *reason* for almost constant horizontal velocity.

(ii) There was a remarkably high success rate in establishing consistency between the vertical velocity and the vertical and horizontal distances. Without hints, most candidates showed that the data gave equal times for the vertical and horizontal motions, or equivalent.

(b) Having found the stone's 'final' vertical velocity, most candidates performed vector addition correctly and gave their answers clearly.

Q.2 **(a)** As a reason for zero moment on Eris we accepted zero force component at right angles to the line joining Eris and the Sun, zero perpendicular distance from Sun to line of action of force, or just force directed towards Sun. Most candidates gave one of these, though there were some garbled versions such as "force not perpendicular to distance between Sun and Eris".

(b) Almost everyone calculated the work done by the gravitational force correctly. Occasionally the factor of cos 64° was omitted.

(c) The great majority calculated the change in KE of Eris, and noted that it was the same as the work done. A minority used the data to calculate the acceleration of Eris in the direction AB, multiplied it by the mass of Eris and then by the distance AB, and commented that this was the same as the work calculated in (b). This is a valid check and was given full credit (even though it was seldom mentioned that the calculated acceleration was only one component of Eris's acceleration).

Q.3 **(a)** Despite occasional claims that it applied only to elastic collisions, the principle of conservation of momentum was usually stated perfectly.

(b) **(i)** Sometimes the vector nature of momentum wasn't properly taken account of, but most candidates found the required velocity correctly.

(ii) Sketches of the momentum-time graph for trolley Y usually showed a good understanding of momentum conservation.

(iii) Using the graph to estimate the mean force during the collision was, regrettably, slightly complicated by the rounded 'corners', but answers based on any reasonable reading of the collision time were accepted.

Q.4 **(a)** **(i)** **I** As expected for a routine calculation, the angular velocity was almost always found correctly.

II Finding the time taken to travel the 10.0 m arc required a little strategic thinking. Some mistakes were made, often involving a factor of $\mathbf{2\pi}$.

III Almost everyone found the acceleration correctly.

(ii) **I** Only a small minority put $\boldsymbol{T} = \boldsymbol{mg}\cos\mathbf{16}°$ rather than the correct $\boldsymbol{T}\cos\mathbf{16}° = \boldsymbol{mg}$.

II What provides the centripetal force on the bob? We accepted: the string, the horizontal component of tension in the string, the resultant of the weight of the bob and tension in the string. Candidates who gave one of these answers usually went on to calculate the centripetal force using their previous answer, and showed its consistency with the acceleration calculated in (a)(i)(III). However, a significant minority could not make progress because they claimed that rotation of the ride provided the centripetal force (rather than providing the *need* for such a force).

Q.5 **(a)** The definitions of shm were usually excellent.

(b) **(i)** Most candidates determined T correctly from the graph and calculated k from it, giving the correct units. A few were confused and tried to involve g.

(ii) $\boldsymbol{E}_{\mathrm{k\,max}}$ was usually calculated correctly using $\boldsymbol{E}_{\mathrm{k\,max}} = \frac{1}{2}\boldsymbol{m}(\boldsymbol{A\omega})^2$. We gave 2 marks out of 3 for those who calculated $\frac{1}{2}\boldsymbol{kA}^2$ but did not specifically tell us that $\boldsymbol{E}_{\mathrm{k\,max}} = \boldsymbol{E}_{\mathrm{p\,max}}$, or show that $\frac{1}{2}\boldsymbol{kA}^2 = \frac{1}{2}\boldsymbol{m}(\boldsymbol{A\omega})^2$.

(iii) Fully correct graphs of $\boldsymbol{E}_{\mathrm{k}}$ against time were in the minority. Often the zeros were in the right places but graphs went negative or 'full wave rectified' sinusoids were drawn rather than smooth curves.

(c) The many candidates who rearranged the equation as $\mathbf{ln}\,\boldsymbol{A} = \mathbf{ln}\,\boldsymbol{A}_0 - \boldsymbol{\lambda t}$ usually went on to gain full marks. A few were seriously confused and took logs of readings from the graph or expected the $\mathbf{ln}\,\boldsymbol{A}$ values to keep halving in equal time intervals.

Q.6 **(a)** **(i)** Most candidates knew how to calculate the density in kg m^{-3} and its absolute uncertainty. The measurements in mm were handled well. Full marks were given for $\boldsymbol{\rho} = (\mathbf{8.9} \pm \mathbf{0.6}) \times \mathbf{10^3}[\text{kg m}^{-3}]$, $\boldsymbol{\rho} = (\mathbf{8.9} \pm \mathbf{0.7}) \times \mathbf{10^3}[\text{kg m}^{-3}]$, $\boldsymbol{\rho} = (\mathbf{8.87} \pm \mathbf{0.64}) \times \mathbf{10^3}[\text{kg m}^{-3}]$. A common fault was giving uncertainties to too many significant figures.

(ii) Finding the number of atoms per m^3 of copper was usually done successfully, though a small minority divided the mass of the block in (a) by the mass of a copper atom. Conversion from u to kg caused little trouble.

(b) **(i)** **I** Almost everyone calculated the number of gas molecules per m^3 correctly.

II The key point, made by most candidates, is that a gas is mainly empty space, between molecules, whereas in a solid the atoms are closely packed. The second mark, often awarded, required a subsidiary point such as a copper atom and a gas molecule usually differing in volume by only a small factor, or gas molecules 'filling the container' by rapid random translations.

(ii) **I** We insisted that the relation between ratio of rms speeds and ratio of molecular masses was derived from a valid starting point: equal molecular KE at the same temperature, or $\frac{1}{2}\boldsymbol{m}\overline{\boldsymbol{c}^2} = \frac{3}{2}\boldsymbol{kT}$. There were many faulty attempts to derive it from $\boldsymbol{pV} = \frac{1}{3}\boldsymbol{Nm}\overline{\boldsymbol{c}^2}$ alone.

II Most candidates successfully used the relationship given in the previous part (even if they had failed to establish it) to find the percentage difference in speeds of nitrogen and oxygen molecules.

Q.7 **(a)** A very easy first mark was given for stating that heat was energy [in transit]. The second, for distinguishing heat from other cases of energy in transit, proved rather more elusive, though most candidates wisely chose to state that heat needed a temperature difference in order to flow – or equivalent.

(b) **(i)** Very few candidates made mistakes in calculating the work done in the constant pressure stage.

(ii) This 6 mark QER question required candidates to explain, using the first law of thermodynamics, whether heat flowed into or out of a gas for each stage in a cycle and for the cycle as a whole. Although most candidates (but not all) appeared to grasp that they needed to consider both the internal energy and the work in each case, quite often this was not done consistently, one or the other being ignored for some stages. A common fallacious claim was that for the isothermal stage, no heat would enter or leave. Perfect or near-perfect answers were quite rare.

Q.8 **(a)** The first mark, a gentle introduction, required picking out from a diagram the stages in a star's life cycle. Although most candidates succeeded it was slightly surprising how many omitted a stage.

(b) Most candidates gave the answer that we had hoped for: telescopes in space avoid the problem of absorption of radiation by the Earth's atmosphere. We also accepted avoidance of image distortion by uneven refraction.

(c) There was considerable success in showing where new stars are forming.

(d) Most candidates sensibly chose to give a photon explanation for radiation pressure in a star. Sometimes it was not made clear that the photons had to encounter matter in the star so that their momentum *changed*.

(e) It was not always stated that increased gravitational forces was the reason why higher mass stars have higher core densities. A significant minority of candidates tried to explain why a higher density led to higher temperature without mentioning or implying nuclear fusion. There were, though, many excellent answers.

(f) **(i)** Wien's law was applied correctly by almost everyone.

(ii) With few exceptions, candidates gained the first mark for pointing out that 150 nm was not in the visible region. The second mark was seldom given. The point had to be made that although 150 nm was the wavelength of *peak* emission, the star would emit plenty of visible radiation [as the luminosity of a very high temperature star will be high].

(g) Most candidates selected equation 1 and calculated the luminosity correctly. As justification that the star had been correctly plotted we were happy to accept that the calculated luminosity lay between 0.001 $\boldsymbol{L}_{\odot}$ and 0.01 $\boldsymbol{L}_{\odot}$. Both marks were often gained.

(h) The first mark, usually gained, was for using equation 3 to calculate the luminosity of a star of mass 10 $\boldsymbol{M}_{\odot}$. Credit was then available for making clear that the luminosity was to be used as the rate of loss of energy and that the available energy was $\boldsymbol{Mc^2} = \mathbf{10}\ \boldsymbol{M}_{\odot}\boldsymbol{c^2}$. This credit could be given by implication to the many candidates who quoted $\text{time} = \frac{\text{energy}}{\text{power}}$ and substituted $\frac{\mathbf{10}\ \boldsymbol{M}_{\odot}\boldsymbol{c^2}}{\mathbf{5000}\ \boldsymbol{L}_{\odot}} = \left(\frac{\mathbf{1}}{\mathbf{500}}\right) \times \text{solar lifetime}$. Once or twice it was pointed out that this is oversimplified because the star's luminosity would decrease as its mass dwindled.

(i) Most candidates stated correctly that white dwarfs of higher mass have lower radii. We did not accept the too specific claim that mass and radius were inversely proportional.

Summary of key points

- Answers to the first three questions revealed a generally excellent understanding of basic linear kinematics and dynamics. Perhaps the least strong area was the vector nature of momentum.
- Handling the equations for circular motion was generally very good. Some candidates did not realise that a centripetal force was just an ordinary force performing a particular function.

- An unexpectedly weak area in simple harmonic motion was the sketching of the graph of kinetic energy against time.

- Calculations of numbers per m^3 of copper atoms and of gas molecules gave little trouble, but many candidates did not recall that molecules of all gases have the same mean kinetic energy at the same temperature.

- Calculating heat flows into or out of a gas using the first law of thermodynamics proved quite challenging even though (or possibly because) only qualitative reasoning was needed. A worrying lack of understanding was shown by the significant number of candidates who claimed that constant temperature implied no heat flow.

- Candidates did not seem fazed by the synoptic character of the last question!

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COMPONENT 2 – ELECTRICITY AND THE UNIVERSE

General Comments

This, the third examination series of the specification contained questions from nearly all sections of the specification along with questions specifically related to experimental technique, data handling and logarithms. In addition, questions were set to test candidates' ability to provide accurate, logical and well-constructed extended responses and to test candidates' understanding of ethical issues related to science in our society.

Examiners were very encouraged by candidates' responses to most questions. Responses to questions on capacitors, resistance in metals, gravitational fields and mutual orbits were particularly encouraging. Responses to questions on Young modulus (and brittle fracture in particular) and circuit theory did not score as well as expected. Uncertainties in measurement were not tested this year in this unit. Rather, questions were set to test candidates' understanding of logarithms in relation to a given expression. Responses, on the whole, were very encouraging, with a good understanding of the required techniques shown by candidates of all abilities. Details are provided below.

As in previous examinations of this component, candidates displayed good mathematical skills, especially in substituting, rearranging equations and using logarithms. However, many of the weaker candidates frequently misread the units on graphical scales (Q5 and 6). Furthermore, a significant number of candidates did not provide full mathematical responses as required for some questions. A good example would be Q5(a) where intermediate steps towards the final expression were often omitted. Units to numerical answers were often incorrect or not given altogether.

Examiners commented favourably on candidates' ability to communicate ideas clearly and succinctly. Responses to the QER question in particular were clear, unambiguous and logically structured, though not always scientifically correct. Spelling, punctuation and grammar was usually very good.

It is a requirement that some synoptic style questions are given in the paper. These can be identified in 3(c), 5(b)(i) and 8(b) and (c). In general, candidates responded well to these questions. Again, details are provided below.

Comments on individual questions/sections

Q.1 **(a)** Few candidates were able to provide a full explanation of the given equation in terms of energy. Many were able to identify Ir as the energy 'lost' as internal resistance in the cell. A significant number of candidates failed to mention 'per coulomb/unit charge' in their responses.

(b) **(i)** Many candidates were able to calculate the internal resistance of each cell, though a significant number determined the internal resistance of both cells, rather than the one cell as required.

(ii) Only a few candidates were then able to calculate the energy dissipated in each cell in one minute. The majority of candidates either failed to include the factor $\times 60$ in their calculations or used an incorrect value for r or V.

(c) Very few candidates were able to provide an adequate answer to this part. Some thought the current would be unchanged. Some thought that the current would double. A few who started on the right track by determining the resistance of the two coils in parallel neglected to include the internal resistance in their calculations. This element of circuit analysis was poorly understood.

Q.2 **(a)** The majority of candidates correctly stated that the variable resistor should be varied to obtain a range of values for V and I.

(b) Only a few of the weaker candidates were unable to use logs correctly to rewrite the equation as required. Nearly all other candidates were successful in their attempts to do this.

(c) The majority of candidates completed the table correctly with nearly all deciding to use $\log_{10}$ or $\log_e$. Both were acceptable. A minority of candidates lost one mark for using an inappropriate number of sig. figs.

(d) A significant number of candidates labelled the axes incorrectly, in most cases by giving labels with units incorrectly. For example, labels such as $\log_{10} V$ (V) were often seen. Labelling without units was accepted as was labelling with units bracketed correctly e.g. $\log_{10}(V/\text{V})$. The majority chose sensible scales and plotted the points correctly. Best fit lines were drawn well.

(e) Most candidates who were successful in (b) understood how to use the graph to obtain values for n and k. In a minority of cases, candidates misread their graphs which led to incorrect answers. Care should be taken when carrying out this simple task.

(f) A significant number of candidates did not state clearly that the best fit line has all the points close to it.

Q.3 **(a)** The majority of candidates gave two valid reasons as to why the capacitance of X is greater than that of Y. However, a significant minority failed to pick up marks due to the vagueness of their responses: *"One has the plates closer together and one has a dielectric"* were the type of responses which could not be credited.

(b) **(i)** Nearly all candidates correctly calculated the total capacitance of the combination.

(ii) Many candidates did not give a clear explanation, including the fact that the charge on both capacitors in series must be the same. Few candidates, for example, used the values of the capacitances given (20 μF and 30 μF) to illustrate their answers.

(iii) Many candidates gave the correct answer of 40 V, however a significant minority gave 60 V as their answer, notwithstanding that $C \alpha \frac{1}{V}$.

(iv) Many candidates were successful in calculating the size of the greatest charge. However, few candidates incorrectly explained the reasons why C_1 stored the greatest charge.

(c) Most candidates scored full marks in this part, providing a clear and logical argument in terms of capacitor energy and the energy gained by the block. The synoptic nature of the question didn't seem to affect candidates, with the use of specific heat capacity and the efficiency of the energy transfer being calculated correctly by nearly all.

Q.4 **(a)** There were many good responses here with the majority of candidates scoring well with the **describe** aspect of the question. Many described how resistance changed with temperature from the superconducting stage to higher temperatures well. Most made appropriate reference to the critical or transition temperature. Fewer candidates were able to **account** for the changing resistance adequately however, with a significant minority describing collisions between electrons rather than between electrons and ions. Fewer again outlined the consequence of these collisions in terms of reduced drift speed and increased resistance. A sketch graph helped some candidates' answers but only if of the correct shape.

(b) In this scientific issues question, it was expected that candidates provided an example of how MRI scanners and particle accelerators are used in society. Two marks were awarded for this. The third mark was awarded for providing clear reasoning as to which one the candidate thought was of greater benefit to society.

Q.5 **(a)** **(i)** Many candidates recognised the need to add the extensions and many gave correct terms for the extension of each of the parts. However, many candidates then wrote down the final expression (which was given in the question) without showing clearly the algebra to get to it.

(ii) A significant number of candidates seemed to miss this question, not showing the additional line on the graph. Many others incorrectly drew in a shallower line.

(iii) Most candidates calculated Young modulus correctly, many by using the line of cross-section A or the line of cross-section $3A$. Some candidates tried using a mean cross-sectional area unsuccessfully. Some candidates were penalised for giving an incorrect unit.

(iv) The majority of candidates were unsuccessful here with many determining the energy stored for only one of the sections.

(b) **(i)** Most candidates completed this part successfully, with clear lines on the graph to show how they obtained the breaking stress. However, a significant number did not convert weight to mass as required and lost one mark.

(ii) Many candidates were able to explain the mechanism of brittle fracture in terms of *crack propagation*, but few were able to give a correct reason, in terms of having fewer surface imperfections and why thinner fibres have a greater breaking stress than thicker ones. Many, for example, referred to the decreased cross-sectional area of thinner fibres.

Q.6 **(a)** Most candidates were able to use the value of the surface potential obtained from the graph and appropriate theory correctly to confirm that the potential at 3*r* was plotted correctly.

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

Most candidates calculated the gravitational potential energy and the escape speed correctly. In some cases, 'error carried forward' was applied in (ii) from an incorrect potential energy value in (i). In many cases this was because the candidate had omitted the factor ($\times 10^6$), thus leading to an escape speed of $1.2\,\text{m s}^{-1}$, which is unrealistic. Candidates should be encouraged to check their workings in these cases.

(c) Most candidates drew a suitable tangent, but many failed to use the corresponding graph values correctly to determine a valid gradient. Many did not give a clear argument around proving the inverse square law relationship.

Q.7 **(a)** **(i) and (ii)**

Nearly all candidates correctly calculated the period and the centre of mass from the centre of the star.

(b) Most candidates went down the route of using Doppler shift to calculate the speed of the star and then compared it with the value gained using $\frac{2\pi r}{T}$, rather than predicting the wavelength shift and comparing it with 2.0 pm. Both methods are valid. Most candidates were successful in confirming the consistency of their answers to (a)(i) and (ii), whichever method was chosen.

(c) The majority of candidates gained this mark by stating that the planet moves in front of the star (or equivalent).

Q.8 **(a)** Most candidates mentioned either the inverse square nature or the fact that both fields were infinite in range as similarities. Many candidates either mentioned that gravitational fields act on masses and electric fields act on charges or the attractive/repulsive nature of the fields as their differences. As in 3(a), some candidates' answers were vague, not relating specifically to gravitational or electrical, and so couldn't be credited.

(b) **(i)** Nearly all candidates were able to confirm the vertical and horizontal forces acting on the sphere were equivalent to the ones given in the question.

(ii) A significant number of candidates drew the electric force vector to the right rather than the left, and a surprising number drew the weight vector upwards. Angles were largely calculated correctly but a significant number then labelled the wrong angle on the diagram. No candidate drew scale diagrams.

(c) A pleasing number of candidates calculated the time correctly, gaining all four marks. Again, as in 3(c), this question had a significant synoptic element which was handled well and with confidence by many candidates.

Summary of key points

- A strong feature of the previous papers in this specification has been the competence shown by candidates in relation to circuit theory. Question 1(c) showed that this was not the case for this paper. In nearly all cases, candidates made valid comments about the impact on current and resistance of adding a coil to the circuit in parallel to the original. However, again in nearly all cases, candidates failed to account for the internal resistance of the cells. This was the cause of most candidates' failure to answer this part correctly.

- Responses to questions which required written responses and reasoning were sometimes too vague and could not be credited. Two examples are given:
  Q3(a) Two parallel plate capacitors X and Y, have equal plate areas. The capacitance of X is greater than that of Y. Suggest **two** possible reasons for the difference.
  [2]

Candidate response: *Because the plates are closer together and there is a dielectric in it.*

It may be argued that the '*it*' referred to in the response is capacitor X, and this is a reasonable response, but it is not definitive. The first part doesn't mention which capacitor has the plates closer together. There is ambiguity and a vagueness to the response which does not warrant any credit.

Q.8(a) State **one** similarity and **one** difference between gravitational and electric fields.
[2]

Candidate response: *They both have infinite range, but one acts on masses.*

In this case the similarity is correct and applies to both fields and a mark can be awarded. However, the reference to acting on mass is vague and incomplete and no mark can be awarded, even by implication. Had the candidate added '*and the other acts on charge'* the second mark could be awarded as it clearly identifies a difference between the two fields, even if it doesn't directly outline which field acts on the mass/charge. A better answer would be '*gravitational fields act on masses and electric fields acts on charges.'*

- Candidates should be encouraged to consider carefully the unit they provide for calculation based questions. In each assessment component, at least one mark is awarded for correct use of units. Examiners decide on the most appropriate question to apply this procedure during the writing stage.
  In this paper, the unit mark was awarded in Q5(a)(iii). It was noted by examiners that many candidates lost one mark here for giving an incorrect unit for the Young modulus, even though the value they had calculated was correct.

- Candidates should be encouraged to consider the validity of their answers, especially numerical answers in the context of the question. A good example of this was often seen in Q6(b)(ii) where 1.2 $m\,s^{-1}$ was often seen as the calculated value for the escape speed of the given spacecraft from the surface of Pluto. This is unrealistic, and a quick glance would have indicated to candidates that the problem lay in mis-reading the graph in the previous question and omitting the factor $\times 10^6$ (MJ on the graph).

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COMPONENT 3 – LIGHT, NUCLEI AND OPTIONS

General Comments

The general standard of performance of candidates is to be highly commended.

Topics
The weakest topics this year were detection of ionising radiation (not through penetration) and pair production Q5.

Language
"Explain" questions were answered well this year with few candidates losing marks unnecessarily through poor communication skills. The 6 mark QER question was answered particularly well (3b) and other part questions also scored highly e.g. 6(d) and 9(a). The part questions that proved to be more difficult were 3(a)(i), 4(a) and 8(c) but this was more to do with the physics than the quality of the explaining.

Mathematics
Few problems with algebra were encountered again this year.

Evaluative questions
Many instances of good answers e.g. 6(d), 7(b)(ii).

Comments on individual questions/sections

SECTION A

Q.1 **(a)** A reasonable minority cannot define transverse and longitudinal waves. One might expect over 90 % correct answers here for a standard definition, but it was not the case.

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

Almost universally correct. The main difficulty was obtaining the correct period because the displacement-time graph started in an awkward place.

(c) **(i) and (ii)**

Only a very small minority did not realise that wave direction and wavefronts are perpendicular. Likewise, nearly all candidates could state that both S and T were in phase with P.

Q.2 **(a)** **(i)** Well answered but a surprising number got this the wrong way round.

(ii) Many candidates stated "wavelength must be shorter than the slit width". Although this gives 180° of diffraction, the intensity of the diffraction pattern drops very quickly as the slit width is decreased. The greatest amount of diffraction is obtained when the slit width is one wavelength.

(b) It was rare to encounter a candidate who could obtain the correct answer for all four diagrams. Strangely enough, each of the four diagrams seemed to provide an equal amount of difficulty.

(c) This was very well answered but most candidates only obtained three marks. It was only the best candidates that realised that the fringe number for 90° could be almost as large as 5.

Q.3 **(a)** This little corner is very specific. When a 2-level system is being pumped using light, the best that can be achieved is equal population in each level and an equal probability of absorption and stimulated emission.

(b) Very well answered. The explanations of 3 and 4-level systems were almost textbook quality at times. The more difficult points to score were the advantages of the 4-level system over the 3-level system.

Q.4 **(a)** This part question caught most candidates by surprise but the syllabus says clearly “different methods used to distinguish between α, β, and γ radiation”. Many candidates scored no marks by describing how to distinguish using different absorbers. Those who mentioned electric or magnetic fields invariably scored full marks.

(b) **(i)** The vast majority obtained full marks for this two-step calculation.

(ii) This part question was meant to be difficult but the majority obtained full marks. Whether to add or subtract background radiation is a difficult concept but the responses here were highly impressive.

Q.5 **(a)** The responses to this question were perhaps not as impressive as expected. No step in the calculation proved to be particularly difficult but many candidates did not know where to start.

(b) Most candidates realised that the excess energy (0.01 MeV) was shared between the positron and electron. Of those, only a small minority could explain that the energy was shared equally because of the equal masses.

(c) Obtaining the momentum of the gamma photon proved to be the most difficult step here but this is far easier for those who can derive/memorise $p = \frac{E}{c}$. The momentum of the electron and positron also proved troublesome but, again, there was a simple short cut for those who memorised/derived $p^2 = 2mE$.

(d) This part question proved to be tougher than expected ($p^2 = 2mE$ was an advantage here too). The very best answers converted the KE of the nucleus to eV.

Q.6 **(a)** Very well answered.

(b) Although slightly tricky, this was very well answered too with perhaps the make-up of the π-meson causing most problems.

(c) Very well answered too although some candidates did not realise that this was a very short lifetime.

(d) This issues question proved to be far more satisfying than previous questions with a large majority of candidates obtaining two or three marks.

Q.7 **(a)** **(i)** Almost universally correct. Very few candidates round incorrectly at this level.

(ii) It was extremely rare to find an incorrectly plotted point and incorrect error bars were almost as rare.

(iii) In general, a little more care is required with the lines of best fit to ensure that no error bars are missed or to ensure that the line passes through the correct extreme of the error bar.

(b) **(i)** This was well answered in general but two marks proved more difficult to obtain than the others. One of these was obtaining the correct final percentage uncertainty in the value of the Planck constant. The other was ensuring that the final answer and uncertainty were written in the correct manner e.g. $(7 \pm 2) \times 10^{-34}$ J s or with ecf $(6.7 \pm 0.7) \times 10^{-34}$ J s.

(ii) There was an improvement in the standard of the responses to this evaluation of data question this year - more of the candidates are making good comments regarding the quality of the data.

(c) It is far better to check the pd when the diode is switched on properly (a current of 10 mA is not a bad rule of thumb for most LEDs). It was good to see that the majority of candidates realised that the longer wavelengths would be invisible. Unfortunately, quite a large minority tried the stock phrase "to avoid human error" which was not specific enough.

(d) **(i)** The vast majority knew that the answer was the gradient of the line. A minority failed to obtain the correct gradient (usually due to powers of ten mistakes).

(ii) Well answered but common omissions were not to mention the energy of the photon and the emission of electrons.

Q.8 **(a)** The conversion from eV to J was not a problem. The main problem was choosing the correct energy i.e. the electron must be raised from the ground level to $n = \infty$.

(b) Very well answered. Probably the most difficult mark proved to be choosing the correct region of the e-m spectrum.

(c) The answers to this part question were slightly disappointing - only a small minority obtained full marks even though the mark scheme was quite lenient.

Q.9 **(a)** In contrast to 8(c), these explanations were generally excellent. A minority obtained the wrong direction for the force on the electrons.

(b) Very well answered.

(c) Quite well answered. Those who remember the equations ($V_H = Bvd$ etc.) are often at a disadvantage because they use the incorrect dimension in the equation (it's important to know what d or t represent in the Hall effect equations).

Q.10 **(a)** Well answered but sometimes cos(5) or N were missing.

(b) The most common mistake here is to talk of flux rather than change in flux (or flux cutting).

(c) Well answered - most candidates obtained full marks. It was rare to award one mark here because those candidates who knew what to do invariably obtained the correct answer.

SECTION B

Q.11 – Option A – Alternating Currents

(a) This standard derivation was extremely well answered.

(b) **(i)** Also very well answered.

(ii) Well answered with many candidates obtaining full marks. Calculator slips were the most common mistakes here.

(iii) A correct equation inevitable led to a correct answer.

(iv) Graphs were usually good but lacking precision e.g. the limits as frequency tends to infinity were poor or candidates missed the point that the current at $2f_o$ was almost 100× less than the resonant current.

(v) A significant percentage of the candidates did not realise that the resonant current would halve.

(c) Another difficult question well answered. As one might imagine, the most common mistake was to realise that the reactance of the inductor was equal to the resistance of the resistor and then conclude that half the supply pd was across each component. This response lost two marks.

Q.12 – Option B – Medical Physics

(a) **(i)** Almost all candidates labelled the higher curve as the higher voltage correctly, however the labelling of the minimum wavelength and line spectra was not as well done.

(ii) Generally well done.

(iii) Again well done by those who attempted the question however a number left this question blank.

(b) **(i)** A number of candidates just restated the question saying that the A-scan can be used to measure depth, as this was in the question it did not merit any marks.

(ii) This was generally well done however, as expected many candidates forgot to divide by 2 (taking into account that they were dealing with an echo) and so lost the last mark.

(c) **(i)** The majority of candidates stated that the half-life should be short (appropriate was accepted) but it needed to be accompanied by a correct explanation as to why for the first mark. The use of a gamma emitter with a correct explanation (less ionising / passes through the body) was not as well done.

(ii) This was surprisingly well done, not just in terms of the number of candidates who answered the numerical part of the question correctly but also in terms of the number of candidates who correctly stated the assumption that the activity of the iodine-125 would not change over this short period of time.

(d) Again the mathematical calculation was well done generally however, it was unfortunate that a significant number did not back up their answer with a correct conclusion for the second mark.

Q.13 – Option C – The Physics of Sports

Candidates attempted all parts of the question and part (c)(i) was answered well by all candidates. Part (c)(ii) proved to be the part that discriminated well with only a few candidates able to gain full marks.

(a) Answered well by all candidates. The common errors resulted in not being able to resolve the tension correctly in order to determine the moments.

(b) **(i)** Definition of angular acceleration was answered well.

(ii) A surprising number of candidates were not able to determine the correct value for the angular velocity with an incorrect answer of $8.52\,\text{rad}\,\text{s}^{-2}$ given.

(iii) The torque was determined correctly by nearly all the candidates.

(c) **(i)** The maximum height was determined correctly by the majority.

(ii) As noted previously; this part was the most discriminating as the correct approach is based on the Bernoulli equation. Some candidates did gain credit for a correct conclusion in that the distance did not change.

(iii) In general; this was answered well with many candidates realising that the drag force is directly proportional to v^2.

Q.14 – Option D – Energy and the Environment

(a) **(i)** This introductory question part resulted in some good responses from candidates, however, overall it was found to be challenging. We were looking for reference to ‘replenishment in a short time period’ or a resource that would ‘last for a long period of time’ here.

(ii) Most candidates were able to successfully show the percentage mass loss to be 0.7 %. Candidates used a number of different methods of showing this successfully. Some candidates converted into MeV in their attempts. A minority of candidates calculated the mass loss correctly but went on to find this as a percentage of an incorrect total mass.

(iii) This question proved more demanding than the previous question part. The first mark required 0.7 % of the mass of the sun to be used. This was missed by some candidates. The use of energy per second was considered by a good number of candidates allowing them access to the second marking point.

(b) **(i)** Most used the equation stated in the question. A good number of candidates were able to determine ‘10°’ using good numeracy skills. They invariably went on to gain two marks. A minority unsuccessfully attempted using other equations from the data booklet.

(ii) Candidates generally answered this question part well. The example calculations on the mark scheme were not exhaustive and candidates found alternative calculations to support their statements. The third marking point proved most difficult with not enough specific detail regarding changes to the Sun’s intensity incident on the cells. General ‘weather dependent’ comments were not deemed specific enough.

(c) **(i)** There were some excellent responses here however there was sometimes confusion between which of U-235 and U-238 was fissile.

(ii) This proved to be a good discriminator. The first marking point was achieved by most candidates. Setting up the ‘$0.7\% \times 1.004^n = 5\%$’ proved to be more challenging for candidates. Some candidates went on to show very good numerical skills in finding a value for n. A small number of candidates realised that substituting 450 for n in the above equation gave a value of 4.8 % and hence more than 450 stages was required. They were awarded full credit.

(iii) The gas centrifuge was the most common response here. There were also a small number of alternatives as stated on the mark scheme. A minority of candidates were not able to access this question part.

(d) **(i)** The first marking point was less well answered than the second. Some candidates did realise that the hydrogen ions pass through the electrolyte and so allow the electrons to travel through the external circuit. As expected, water was the well-known waste product from the process. This allowed many to access this marking point.

(ii) Many candidates gained credit for the dependence on the type of power station that was used to produce the electrical energy. Some candidates then went on to discuss what could then happen to the released carbon.

Summary of key points

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

1. Explaining the advantages of a 4-level laser system over a 3-level system.

2. Differentiating between α, β, and γ radiation using electric or magnetic fields.

3. Tightening up the final representation of value, uncertainty and unit. A typical **bad** example being 24 ± 0.9 μF and a good example being (24.0 ± 0.9) μF.

4. Explaining the origins of emission and absorption spectra.

5. The useful relationships between momentum and energy for particles and photons ($p^2 = 2mE$ and $p = \frac{E}{c}$).

PHYSICS

GCE A LEVEL

Summer 2019

COMPONENT 4 – PRACTICAL ENDORSEMENT

General Comments

The second cycle of monitoring the practical endorsement covered the period September 2017- April 2019. Eduqas visited most centres doing practical endorsement in year one of this cycle. The third cycle of visits will commence in September 2019.

Approx. 90 % of centres passed on the first monitoring visit in the second cycle. This is compatible with the outcome from the first cycle of visits and similar to other awarding bodies. Centres which failed the first monitoring visit were given support and were visited a second time in the same subject. All centres which failed the first visit made by Eduqas subsequently passed the second visit.

Centres are commended for the way in which they have embraced the practical endorsement. Eduqas monitors saw many examples of good practice and assessment used by schools and colleges.

Comments on individual questions/sections

Monitors were required to examine evidence of how the school manages practical endorsement. In common with other awarding bodies, monitors are required to view the following evidence:

- Plans for completing and assessing practical work.
  The centre is required to plan to complete the necessary range of practical work required by the specification.
- Teacher records of candidate assessment.
- Candidates' laboratory books.
- Teacher assessment of a practical class.
  The monitor is required to observe a year 13 practical class in which assessment of CPAC is taking place and speak to the teacher about the assessment of the relevant CPACs linked to the session.

There are several key features that characterise centres that successfully implement practical endorsement:

- Clear planning of both practical work and the CPAC statements to be assessed in each practical.
- Candidates are well informed about practical endorsement, the meaning of CPAC statements and the outcome of each assessment.
- Practical books are used in 'real time' at the bench by candidates when completing a practical.
  Practical books should be used in the lesson. We do not expect to see practical books which are in immaculate condition! Candidates should not write on scraps of paper and later copy the work up neatly into practical books.
- The teacher targets appropriate CPAC for assessment in the practical lessons.

- Suitable feedback is given to candidates.
  This is particularly important when a candidate does not achieve a CPAC; why have they failed to achieve a CPAC statement and what they need to do next time to evidence it? We understand that there are limits to the feedback that may be given. Use peer assessment and self-assessment to reflect on practical work. Encourage candidates to self-annotate work to facilitate learning. This is particularly helpful if you give verbal feedback.
- There is evidence of good communication between staff teaching on the same qualification.
  Where a number of teachers are involved in the delivery of a qualification, there should be evidence that centres standardise their approach.
- Information from CPD is fed back to other members of the team delivering the qualification.

CPAC statements

Centres are reminded that in order to award a pass for practical endorsement, a candidate needs to 'consistently and routinely meet the criteria'. This means there needs to be evidence of multiple occasions where a candidate evidences a pass for each CPAC statement. It is important that suitable opportunities have been built into the assessment plan which allow candidates to generate this evidence.

CPAC 1 This is generally well assessed by the majority of the centres visited.
In a few cases, candidates did not always carefully follow instructions during the observed practical. When this happens, the candidate should not achieve the CPAC. It is therefore important that candidates are carefully observed when they conduct their work.
When assessing more complex procedures, teachers may wish to use a check list to aid assessment. This is particularly helpful in standardising assessment when a number of teachers are involved assessing the same scheme.

CPAC 2 This is the most difficult CPAC for candidates to evidence since it involves higher level skills. Generally, we do not expect to see this CPAC assessed in the first two terms of an A level course. However, we do expect to see evidence of some assessment of this criterion by the beginning of the second year of the A level course. Some centres make use of the period at the end of the first year to introduce the assessment of this CPAC statement. Please make sure that you know where and when you are going to assess this CPAC. It is also important that sufficient time is given to candidates to develop the necessary skills before assessment occurs.

CPAC 3 There is no need to assess this skill every time a practical is completed. There are plenty of opportunities to assess this CPAC so choose the occasions where there are more significant risks or hazards.
CPAC 3(a) requires learners to identify hazards and asses the risks associated with the hazards. Some centres choose to assess this by asking candidates to write a risk assessment. This is a valid means of assessment although it goes beyond what is required for the criterion. If a risk assessment is not written by the candidate then it will be necessary to consider how to assess this. A simple method used by some centres is to ask candidates to identify to the teacher the hazards / risks of a technique while they do the experiment.

Successful completion could then be marked on a tick sheet.
CPAC3(b) should be assessed by observation of learners conduct during a practical session.

CPAC 4 (a) Making accurate observations

Observations should be made directly into their practical books. They should not be written on to scraps of paper and copied up later. Tables of the candidates' **own** devising should be used to record information. The tables should have appropriate headings and units. It should be noted that it is a requirement that candidates record units in the table to achieve the criteria. Do not use proforma with blank tables when assessing this skill.

(b) Obtaining accurate, precise and sufficient data …….

Please carefully check learners' data. Is it recorded to appropriate precision? Is there sufficient data? Is the data what you expect?

CPAC 5 Please remember the difference between CPAC 4 and CPAC 5.

- CPAC 4 is about recording data 'live' into appropriate tables.
- CPAC 5 has two main elements: (1) processing data and (2) referencing information.

(1) Processing data

There should be evidence of learners processing data using graphs and calculations. Centres should require candidates to draw graphs by hand on some occasions and, on other occasions, to use software (e.g. Excel) to draw graphs.
Make sure graphs are constructed correctly, i.e. there is a title, each axis is correctly labelled, points plotted correctly, an appropriate scale used etc.

(2) Referencing data

Candidates **must** show evidence of referencing sources of information. The evidence produced towards this aspect of the CPAC varies considerably among centres. Some have candidates demonstrating referencing on multiple occasions, even using the Harvard System (which exceeds our requirements), while, in other centres, it is rarely evidenced.
Opportunities for assessing referencing should be built in from early in the course. The information referenced may be, for example, data or a quote; the information may come from a textbook, journal, website EDUQAS data sheet etc.

A few centres, and therefore candidates, still confuse referencing with a bibliography. There are important differences.

Summary of key points

- Successful delivery of practical endorsement needs careful thought and planning. Ensure that you review and adapt these plans as you deliver the qualification. Make sure that there are ample opportunities for candidates to evidence each CPAC statement.

- Ensure that candidates are engaged with practical endorsement and its assessment. Candidates need to have the practical endorsement and its assessment explained at the beginning of the course. In addition, candidates must be clearly informed of the CPACs that are assessed in each practical session.

- Review your assessment of CPAC with colleagues. This is particularly important when new members join your teaching team. Make sure that practical endorsment is an item on the agenda of subject meetings.

- Please also remember that candidates **must** be informed if they have achieved the practical endorsement **before** the centre submits outcomes to Eduqas in accordance with JCQ requirements. Eduqas will not change centre gradings if a centre has passed the monitoring visit.

- Centres are reminded to download the following document which provides support on interpreting CPAC: 'The Practical Endorsement Standard'.

WJEC
245 Western Avenue
Cardiff CF5 2YX
Tel No 029 2026 5000
Fax 029 2057 5994
E-mail: exams@wjec.co.uk
website: www.wjec.co.uk