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Physics A PHYA5/2D

(Specification 2450)

Unit 5/2D: Turning Points in Physics

Report on the Examination

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GCE Physics, Specification A, PHYA5/2D, Section A, Nuclear and Thermal Physics

General Comments

The exam had good discrimination and the complete range of marks from zero to full marks were seen. Students showed some general areas of weakness in tackling this paper. The first was a lack of clarity when answering standard questions that should have been extremely straightforward. So the typical mark for explaining what is meant by the term ‘binding energy’ was one mark out of two. The same mark was also a typical score in question 4(b). The second area of weakness across a range of abilities was question parts 3(b) and (c) in which many students could not deal effectively with solid angles, detection efficiency and the inverse square relationship between range and intensity of gamma rays. However, other topics were done well resulting in a paper that was of very comparable difficulty to previous papers.

Question 1

In part (a) almost all students knew the correct equation to use and only the less able students made errors. The first of these was to use the mass of water in the heating chamber rather than the rate of flow of water. The second error, which was less common, was to try to convert between Kelvin and Celsius by adding 273 to the answer. Again in part (b) it was only the less able students who had any difficulty. The problem was that they could not cope with being given the rate of supply of energy. Overall the question was done well.

Question 2

Even though part (a) needed a little thought almost all students obtained the correct answer. By contrast part (b)(i) was simply a factual recall question, which was answered poorly by a significant minority. The main error was for students not to state the energy needs to be given out or is required, when a nucleus was formed or broken up. It was common to see written, ‘The energy to keep the nucleus together’. In part (b)(ii) a majority of students simply read the value from the graph and gave an answer near 7.88 MeV without appreciating the ‘per nucleon’ on the y-axis of the graph. Part (c)(i) was done well by most students. Some students missed marks due to a lack of care in choosing specific coordinates for the graphs to pass through. Most students made a good attempt at part (c)(ii). Part (c)(iii) was more difficult and only the better student could correctly combine the two equations required to answer the question. A common mistake made by a few students who looked as if they were going to get the correct answer was for them to confuse the time units they were using. These students obtained the correct answer but then multiplied it by $60 \times 60 \times 24 \times 365$.

Question 3

A majority of students could not give two clear specific sources of background radiation. The answers given in response to question part (a) were all too often of a general nature and too vague to be worthy of a mark. For example, ‘power stations’ or ‘the air’. The answers needed to be clearer statements like, ‘radioactive material leaked from a power station, or radon gas in the atmosphere. As only one mark was being awarded only one detailed source gained the mark provided the second point was in some way appropriate even if poorly stated. Part (b)(i) was a very good discriminator. More able students realised that a comparison of areas was required to answer the question. Part (b)(ii) was also a good discriminator. Only the top 20% of students used the detection efficiency factor as well as the fraction of gamma rays hitting the detector to obtain the correct answer. Most used only the 1/400 detection efficiency. Students were more successful in choosing the correct unit. Part (c) was interesting in that students either attempted the question successfully or they left this section blank.

Question 4

Part (a)(i) was an easy introductory question, which most students got correct. Part (a)(ii) was also successfully attempted in a majority of scripts. Use of the ideal gas equation again was more popular than using pressure is proportional to temperature. A small percentage of papers gave answers to only 2 significant figures rather than the 3 required. A majority of students only scored one mark out of two for part (b). They correctly referred to the random motion but failed to refer to a mean when giving some quantity, such as kinetic energy, that increases with temperature.

Question 5

Only the less able students tried to draw graphs of completely the wrong shape by showing peaks etc. in part (a). A significant minority however failed to get the mark because they drew the graph with a horizontal asymptote. Part (b)(i) also scored well. Only the bottom 25% had difficulty over the use of the density equation or the volume of a sphere. Not many students got caught out by powers of 10 in the calculation but this could have been because of the 'show that' nature of the question. Part (b)(i) proved to be much more difficult and only the top third of the students scored the 2 marks. Some unsuccessful attempts showed the equation for the radius in terms of the atomic mass number but they did not know where to obtain r_o from the information supplied. Part (c) was a good discriminator and the mean mark was between 3 and 4 out of 6. Two thirds of the students supplied information about alpha particles being scattered electrostatically. Many hinted at the idea that the least distance of approach is connected to a measure of the radius of the nucleus. This group of students also referred to electrons behaving as waves to explain diffraction. The bottom third of students scored poorly because they did not add much information to what they would have covered at GCSE. It was common to see an explanation of the scattering distribution of alpha particles and give nothing else. In this way they almost completely ignored the wording of the question. Students had obviously been taught this section of the specification in a vast number of different ways. To give students the greatest benefit, no individual marking point was required for any particular score. Any of the selection of points listed in the marking scheme were noted and taken into consideration along with the quality of communication. As a consequence, for example, some students scored full marks even though they did not refer to any equations. Most students lost marks by not including enough of the points listed. They did not include many statements that were wrong apart from one notable exception. A majority of students who gave the equation to find the least distance of approach for an alpha particle related the initial kinetic energy of the alpha particle with the Coulomb force expression rather than the potential energy expression.

GCE Physics, Specification A, PHYA5/2D, Section B, Turning Points in Physics

Question 1

In part (a) most students knew that the beam was attracted towards the positive plate because electrons have a negative charge. Many students realised the electrons were accelerated downwards but failed to recognise either the acceleration was vertically downwards or the vertical component of velocity increased. Relatively few students stated that the horizontal component of velocity was unchanged. A common misconception was that the electrons accelerated downwards because the force on each electron increased as it moved closer to the positive plate.

In (b)(i) most students stated either that the magnetic field needed to be adjusted or it needed to be reversed, few students stated the field needed to be reversed and adjusted. In (b)(ii), most students equated the relevant force expressions but a significant number did not identify which expression was which.

In part (c) many students scored full marks with a clear and accurate calculation. A significant number of students knew the correct equation to be used but were then unable to gain further credit because they then inserted the value of e or *m* from the data sheet into the equation to calculate *e*/*m*. Students who used a value of *e* or *m* from the data sheet to calculate *e*/*m* were unable to score beyond the first mark.

Question 2

In part (a) many students scored full marks by depicting as well as describing an electromagnetic wave. Those who limited their account to a description often failed to mention the fields were in phase or the direction of propagation was perpendicular to both fields. A significant number of students considered polarisation of an electromagnetic wave causes loss of the electric wave or the magnetic wave.

In part (b) many students did realise that the equation for the speed of electromagnetic waves gives a value equal to the speed of light but few students stated its value or appreciated the value of the speed of light with which the calculated value was compared was obtained by experiment.

For part (c) although most students in (i) chose to explain the induced emf by considering the magnetic wave variations, very few students provided a good explanation. Relatively few students answered in terms of the electric field variation. Many students knew the magnetic flux in the loop changed but failed to state the flux linkage changes continuously or that the magnetic field is perpendicular to the plane of the loop. Some students failed to score because they did not make clear whether their account was in terms of the magnetic wave or the electric wave. In (ii), very few students mentioned the significance of the wave being polarised although the best students did know that emf was zero at 90 degrees because the flux linkage was zero or that the electric field was then perpendicular to the loop.

Question 3

In part (a) it was pleasing to see some well-written accounts that covered most if not all the relevant facts. Many students failed to support a reasonable or good account of one of the two properties with a similar account of the other property. Many students who were able to supply a reasonable ‘wave’ explanation of the double slits experiment often gave a limited account of photoelectricity as a particle property with little more than a statement of the meaning of the threshold frequency. Explanations often lacked depth as many students failed to link the threshold frequency to the work function and the photon energy equation. However, a significant number of students did provide a brief outline of why interference fringes could not be accounted for using corpuscular theory or why the threshold frequency could not be explained using wave theory.

In part (b)(i), many students did not realise the relativistic mass needed to be calculated even though the speed of the electron was given in terms of the speed of light. In (ii) and (iii), whereas most students were able to calculate the photon energy in (ii), only the best students were able to calculate the kinetic energy in (iii). Frequent errors included the use of $\frac{1}{2} mv^2$, some with the correct mass of the electron and some with its rest mass. A significant number of students did calculate the total energy correctly but then failed to subtract the rest energy.

Question 4

In part (a) although few students stated the condition for the formation of a bright or dark fringe, many students did know that the shift of the interference pattern occurs because the path difference or the phase difference changed when the distance is changed.

In part (b) many students did appreciate that the speed of light was thought by scientists to be affected either by the motion of the Earth or by an ‘ether wind’. However, only a minority of students appreciated the distances travelled by each beam was unchanged or that the time difference between the two beams changed on rotation. Students often referred to a change in the time taken by the beams rather than a change in the time difference on rotation. Many students lost a mark as they did not refer to the rotation causing a change of the phase difference or a change in the optical path difference.

In part (c) most students appreciated the observation that the fringes did not shift led to the conclusion that absolute motion does not exist.

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