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Physics A PHYA5/2B

(Specification 2450)

Unit 5/2B: Medical Physics

Report on the Examination

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GCE Physics, Specification A, PHYA5/2B, 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, PHYA5/2B, Section B, Medical Physics

General Comments

Last year the initial comment made was, 'The paper was accessible to the students and there did not seem to be any problems with allowing themselves enough time to answer this section. It is still the case that the written answers are problematic for many of the students who fail to express their answers clearly'. This is equally true this year with all questions being attempted by most students, but with many of the answers losing marks because they were not written with sufficient detail or care. It must be emphasised to students that this is an A level examination where attention to detail is needed to score high marks.

It is recommended that all teachers of this option use the support booklet on Medical Physics. It can be downloaded here.

Question 1

Question 1 was related to the eye and allowed most students to attempt all parts. Part (a)(i) required a knowledge of accommodation and produced some good answers. However, there were too many vague answers such as 'ciliary muscles change shape to adjust the power of the lens' or 'the lens becomes short and wide' and the lens becomes thicker'. In part (a)(ii) many answers only scored 1 mark as only one change was mentioned. A significant number of students confused the iris with the pupil, suggesting 'the iris opens wider in dim light and will get smaller in bright light'. A noticeable number thought that the cilliary muscles controlled the iris. Other students wrongly suggested that the pupil was reduced in size as less light was needed. Part (b) brought more confused statements such as 'the colour is less bright in dim light' rather than grayscale images are seen in very dim light, and 'the image is less focussed in dim light' rather than the resolution of the image is poorer in very dim light. In part (c)(i) we were looking for reference to perpendicular planes, but this was often missing. Part (c)(ii) was again a part where some student missed the mark writing 'the eyeball is not spherical' or 'irregular shaped lens or cornea' rather than relating the answer only to the surface of the cornea not being spherical. Part (c) (iii) produced the highest percentage of correct answers.

Question 2

Question 2 was related to the ear and the two relative intensity scales, dB and dBA. In part (a)(i) many students failed to gain the mark as they were unable to explain why the reading would be 60 dBA, failing to express clearly that the frequency of 1 kHz was the reference frequency at the threshold of hearing. Part (a)(ii) had the most blanks of any question on the paper. Those students who attempted this part could clearly be seen as those who had a good idea of what was happening and those who were guessing. Part (b)(ii) brought its own problem with the initial calculation of intensity 5m from the source. There were a significant number of students who said that the intensity was $2/5^2$. Those who failed to get this calculation correct were given some credit for using their value in a further calculation.

Question 3

Question 3 was related to the use of optical fibres in an endoscope. Part (a) looked at the refractive indices of the fibre and surrounding air and was poorly answered. There were very few students who recognised the small difference in refractive index between the core and the cladding. Poor answers showing continually varying values in all regions including air were common. This was very disappointing as it is related to A/S work. Part (b) produced better answers with many students gaining two marks. Poor expression such as 'non-coherent bundles transfer light' or 'coherent bundles form an image' was again responsible for some students losing marks.

Question 4

Question 4 was related to ultrasound scans. Part (a) was the part where written communication was examined and related to prenatal scans. This was felt to be a topic that the students would be able to write on in a logical manner, but most answers were lacking in detail and coherence, with poor spelling and sentence construction. The use of a multi-array probe in a B-scan was very poorly described and very few answers could be graded in the high level as good to excellent. Many students still refer to

the gel used in ultrasound as 'Conducting' confusing this with the gel used in an ecg examination, even suggesting that the patients stomach should be rubbed with sandpaper to remove unwanted hairs. . Many students suggested that the ultrasound was diffracted or scattered at boundaries. The reasons for the partial reflections were not often given. The use of the gel to eliminate air was often not discussed. Students often referred to the scan being safer than using X-rays, but failed to state that this was because ultrasound is non-ionising. Part (b) provided many students with a single mark. Very few students related the length of pulse to the short distances travelled and thus the short time available between the start of the transmitted and reflected pulses. Several students gave incorrect answers suggesting that the short pulses were used to allow the reflected pulse to be received before the next pulse was transmitted.

Question 5

Question 5 was related to X-ray production and use. Part (a) (i) and (ii) were related to A/S work and although there were good answers which showed a clear understanding of the principle needed in part (i), there were far more answers which had students trying to use the general equation for kinetic energy with random values being substituted for the electron's speed. A wrong answer in (i) was carried forward to (ii) where students were able to gain both marks on offer. There were better answers in part (ii), but random equations such as that for the deBroglie wavelength were often seen. Part (b) was to do with a simple description of a CT scan. Good answers were seen where students were able to express clearly and concisely the main points of the scan. However, too many students again failed to score high marks by either contradicting themselves or by being too vague in what they were writing. Answers such as 'the CT scanner rotates' rather than the X-ray source rotates. From some answers it seemed that students hadn't covered this topic, and instead of describing the CT scan, they thought they would make up for it by describing how X-rays are produced, or how images are obtained by fluoroscopy.

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