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Physics A PHYA5/2A

(Specification 2450)

Unit 5/2A: Astrophysics

Report on the Examination

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GCE Physics, Specification A, PHYA5/2A, 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 $60\times60\times24\times365$.

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, PHYA5/2A, Section B, Astrophysics

General Comments

The Astrophysics paper this year consisted of a mixture of calculation questions, diagrams and questions requiring extended writing. The paper gave students opportunities to demonstrate their knowledge and understanding across the specification, and marks were achieved across the whole mark range. There was no evidence to suggest that students lacked time to complete this examination.

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

Question 1

Most students were able to draw the two ray diagrams required in part (a) satisfactorily. However, marks were lost by students who labelled the principal focus at the image position, and by those who drew a diagram for a diminished, or same sized, image. The virtual image caused more problems, particularly with students bending construction lines to fit the image in the space available.
The calculation in part (b)(i) was also answered well by the majority of students. The negative value of the image distance caused problems for a small number of students, and some lost a mark by writing their answer to too few, or too many, significant figures.
All three properties were required for the answer to part (b)(ii). As has been stated before, the three properties are related to the size (magnified/diminished/same size), orientation (upright/inverted) and nature (virtual/real). Although alternatives for magnified and upright were accepted, no credit was given for “imaginary” as an alternative to “virtual”.

Question 2

The definition of quantum efficiency required in part (a) proved to be quite demanding. Although several alternative answers were given credit, the mark was lost by students who failed to refer to the photons incident on the CCD in their answer. There were also a significant number of answers suggesting that the students had not come across the term before.
The calculation in part (b)(i) proved to be very straight forward for the majority of students. There were some careless mistakes with students inverting the values when substituting them into the equation, or incorrectly converting nanometres to metres.
The calculation in (b)(ii) proved to be more demanding. Some students had difficulties converting the two distances into the same unit, despite the conversion factors being provided in the data booklet. Some students were also confused by the two values of radius quoted, and tried to include them both in their answer by adding, subtracting or averaging them. The inclusion of the wavelength (750 nm) in answers was interpreted as a physics error and no credit was given. Another relatively common problem was due to students calculating their answers in degrees and failing to change the unit in the answer line, or convert their answer to radian.
Whilst there were many very pleasing answers to (b)(iii), many students failed to get the mark because they assumed that the problem was due to the angular resolution of the telescope, despite having correctly shown that the angular separation of the planet and star was greater than the angular resolution of the telescope. Many correct answers suggested that the planet would be too dim, but there were also many other approaches that gained credit.
Question 2(c) incorporated the quality of written communication assessment. Most students were able to write about the telescopes they have studied. Unfortunately a significant number simply wrote down everything they knew about telescopes without restricting themselves to three parts of the electromagnetic spectrum, or to siting and size. Irrelevant material included descriptions of chromatic aberration for example. There was also evidence for confusion about what parts of the spectrum do get through the atmosphere, students commonly suggesting that x-ray and gamma-ray telescopes can be ground based, or that radio telescopes need to be in orbit. There was also confusion between infra red and ultra violet radiation.

Question 3

Although the majority of students were able to correctly state the definition of absolute magnitude in part (a)(i), there were a significant number who stated the incorrect distance (1pc and 1AU were common) or related the magnitude to the luminosity rather than brightness.
The explanation required in part (a)(ii) proved to be slightly more demanding. Many correct answers simply referred to m-M for the two stars. Incorrect answers included references to temperature, or only one of the magnitudes as evidence for distance.
Most students performed the calculation required in (b)(i) correctly. However, there continues to be some evidence for confusion with the unit of the constant in the equation. Some students interpreted the "m" as milli, or even apparent magnitude, and others interpreted "K" as Boltzmann's constant.
The graph in (b)(ii) produced a range of responses, with students commonly crossing the relative intensity axis with their lines, or drawing lines that do not tend towards the wavelength axis on the right hand side. Many students correctly labelled the wavelength scale, although some failed to see that the unit of nanometres had already been written on the scale.
The answers to parts (c)(i) and (c)(ii) were given correctly by the majority of students, and, although it proved to be slightly more demanding, there were some very good answers to (c)(iii). These included a correct statement that, for Hydrogen Balmer absorption lines to be present in the spectrum of a star, the atmosphere of the star needs to be hot enough to have hydrogen in the excited n=2 state.

Question 4

The calculation in part (a) was answered correctly by many students. Marks were lost by students who had problems matching the speed and distance units to the Hubble constant. There were also several students who made simple algebraic errors rearranging the Hubble equation. Credit was given to unit answers consistent with their calculation, but only "Mpc" or megaparsec was given a mark if there was no calculation performed.
In part (b), only a minority of students were aware that quasars were discovered due to their powerful radio wave emissions. This is explicit on the specification, but many students would probably benefit from learning the story of how the first quasar was discovered.