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Specification A

PHYA5/2A 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 was very accessible to candidates and many good scripts were seen, some with full marks. The overall standard of writing was very good and the paper as a whole did not produce many scripts with scores in single figures. The majority of candidates had prepared well for the exam. The main difficulties for candidates were expressing their ideas clearly in the descriptive questions.

Question 1

Almost all candidates knew which equation to use in part (a) and only a small minority used the wrong temperature change.

In part (b) most candidates obtained full marks.

Part (c) turned out to be a very good discriminator. About one third of candidates were not using the heat energy released by the lead, as it cooled, in their calculation. These candidates either used their answer to (a) or (b) or the sum of the two. In addition another 10% calculated the incorrect temperature change.

Part (d) was answered well on the whole. The most common error by candidates was to not say where the heat energy might go in their answer. Candidates simply said that heat is lost.

Question 2

This question was a good discriminator. Most candidates, in part (a), knew how the core of the reactor functions. Some candidates too readily used the wording of the question as their answer. Others did not refer to neutrons even though this was asked for in the question. One example of a phrase given by candidates that did not quite answer the question but sounded reasonable was, ‘the power levels were kept constant by keeping a constant rate of fission using control rods’. This offers much of what was in the question itself and it does not refer to neutrons. The quality of the writing was generally good.

Again question (b) was a good discriminator. The majority of candidates were aware that fission products are normally unstable because they tend to be neutron rich or that they release beta and gamma rays. Less able candidates thought used fuel meant that they had undergone alpha emission.

Question 3

Less than half the candidates could explain the meaning of the decay constant. By contrast almost all candidates could find the half-life in part (b) and a majority could answer part (c). Some candidates did not gain credit because they conveniently removed 10^{12} in their calculation without showing the division. So lines like, $1.15 \times 10^{12}\,\text{Bq} = 1.15\,\text{Bq}$, were seen.

Most candidates who tackled part (d) using the exponential decay of the activity equation got full marks. Only a few candidates could not rearrange the equation. By contrast almost all candidates who tried to use the exponential decay in the number of nuclei got confused. Most had numbers of nuclei on one side of the equation but activity on the other.

Part (e) did discriminate but only between scoring zero marks or one mark. Very few candidates attempted two reasons. Most acceptable answers to this question were difficult for the candidate to express. For example, in question (d) it states that the decay rate due to carbon-14 is 0.65 Bq, indicating it is a corrected count rate. So an answer to part (e) like, 'the background can effect the result', is not acceptable. This is not the same as saying it is difficult to obtain the results for the sample activity because the background activity is high in comparison. This example is also ambiguous in that it suggests the surroundings can influence the rate of decay. Another answer that was not acceptable was, 'radioactive decay is random so it's bound to give false values'. To gain a mark following this line of thought it was necessary to refer to its effect on the statistics. The most common answers that candidates found easy to express included the following; the tree died well before the boat was made; or the boat was repaired later in its life with fresh wood; or that carbon based microbes died in the wood when the boat was rotting at the end of its useful life.

Question 4

Part (a) proved difficult for less able candidates. Some drew straight lines and others tried to force the curve to intercept the volume axis. The less able candidates sometimes marked correct points on the grid but did not draw a line. It seemed that some less able candidates followed the wrong order in tackling this part. They drew the curve before they marked points on the grid. As a result the points were just randomly placed on the curve they had drawn.

Part (b) (i) was done well by most. Candidates who used the alternative equation $PV = nRT$ often stopped when they had found the number of moles of gas. Part (b) (ii) was much more discriminating with less than 50% of candidates obtaining the correct answer. Many candidates did not have a clue whereas others could find the mean kinetic energy but then did not follow this up by finding the total kinetic energy.

Although part (c) looks like a basic question it did discriminate well. It was only the more able candidates who scored full marks. Many did not know what the question was getting at and guessed. Sometimes these candidates did score the mark associated with molecules moving in random motion. In other cases candidates did not complete their statements fully. For example, stating 'atoms travel in straight lines', rather than, 'atoms travel in straight lines between collisions'.

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

General Comments

This question paper produced marks across the whole mark range. All questions were accessible and some very good answers were seen. There was a balance of numerical questions, which were generally well answered, and questions requiring extended prose, which tended to be much more demanding. Diagrams were often drawn poorly by candidates resulting in careless mistakes and lack of detail. There was no evidence that candidates ran out of time. Unfortunately, there was evidence that many candidates were poorly prepared for this option.

Question 1

In part (a), although the ray diagram for an astronomical telescope is fairly standard, relatively few candidates achieved all three marks. Common errors included drawing axial rays, failing to draw a principal axis, not labelling the common principal foci, rays emerging from the eyepiece with no regard to their direction, rays bending on the principal axis at the centre of lenses and rays being interrupted at the intermediate image. The position of the principal foci also caused problems. Several candidates put the point closer to the objective lens, or half way between the two lenses.

The calculation in part (b) (i) proved to be far more accessible, with many candidates achieving both marks. Of those candidates who did not achieve this, many knew the equation for the magnification but could not express the relationship between focal length and the distance between the lenses. It was also fairly common to see answers which assumed a value of 3.7 m for the objective lens focal length, calculated a value for the eyepiece focal length, and then subtracted this from 3.7 m to obtain a corrected objective lens focal length. This iterative method was deemed worthy of some credit, but did not gain both marks.

The two step calculation in part (b) (ii) caused more difficulties for many candidates. It was fairly common to see incomplete answers, where candidates failed to multiply their unaided angle by 50. Candidates using the arcsin or arctan function to calculate the angle often gained full credit, and it was pleasing to see that most of them handled the use of radians successfully.

In part (c), a common problem with the diagram to show dispersion was that many students confused chromatic aberration with spherical aberration. A diagram with red and blue light entering the lens along separate paths and being focused in different places was fairly common. This response was not awarded credit. Other candidates made no reference to colour or wavelength, or failed to complete the diagram to show some form of focusing, either by rays crossing the principal axis, or by drawing a pair of rays crossing from the top and bottom of the lens.

Question 2

The calculation of distance using apparent and absolute magnitudes in part (a) was very well done on the whole. Common errors included; the use of natural logarithms rather than base 10; using incorrect values for the magnitudes, so that the difference became +2.8 rather than –2.8 for example; and algebra problems. This question provided the opportunity to test units, and most candidates knew that the equation provided a distance in parsec. Other units of distance were not given credit unless they were consistent with the method of calculation.

Most candidates knew that the calculation in part (b) (i) required the use of Stefan's Law and either calculated the ratio, cancelling the constants or calculated each power separately and worked out the ratio, both of which could gain full credit. Although this question was generally well answered, some candidates did not square the diameters (or radii) of the stars. Several candidates also calculated the volumes of the stars rather than their surface areas.

In part (b) (ii), generally, the relationship between apparent magnitude and brightness was not understood well. There were some imaginative attempts to obtain the value of 8000. The best answers stated that a difference in magnitude of 5 was equivalent to a difference in brightness of 100, and used this and the difference in magnitudes to obtain the correct answer. The use of Pogson's Law was another acceptable method of obtaining the correct answer.

Part (b) (iii) tested the students understanding of the relationship between temperature and spectra and it was generally poorly answered. It was common to see answers which tried to involve the surface area of the stars, rather than concentrating on the difference in the amount of their power output that would be in the visible region. The best answers often quoted Wien's Law, with many candidates even calculating the values of the wavelength of the peak in the intensity curve. They then went on to state that, being hotter, Sirius B produced more of its total power output in the UV region compared to Sirius A. The ratio of brightness is therefore much greater than the power ratio as the absolute magnitude deals with only visible light, whereas the power output is across all wavelengths.

Question 3

Unsurprisingly, perhaps, part (a) was one of the most accessible questions on the paper. There was some evidence of confusion. For example some answers discussed problems of interference with Earth based sources of X-rays.

For part (b), within this specification, the defining property of black hole that it has an escape velocity greater than, or equal to, the speed of light. References to singularities were ignored. No credit was given to answers which referred to things being 'sucked in'.

Part (b) (ii) was the most accessible question on the paper. Candidates who did not get both marks tended to forget to square the speed of light, or left out the factor of seven.

In part (c), the question on the CCD was a fairly regular feature of the legacy paper, and there was some evidence to suggest that many candidates simply learned the mark scheme from previous exams. However, there was a lot of confusion with the photoelectric effect and even with absorption spectra. Some answers also suggested that the electrons were promoted *from* potential wells, or that somehow the photons themselves were being stored.

Question 4

Part (a) was used to assess Quality of Written Communication. It produced answers across the whole mark range and was one of the highest discriminators on the paper. The specification approaches the ideas behind the accelerating Universe as a controversy. There are two conflicting pieces of evidence about how far away distant galaxies appear to be. Type 1a supernovae can be used as standard candles – they have a distinctive light curve with a well defined absolute magnitude peak. Using this value (–19.3) and the measured apparent magnitude peak gives one value of distance. The other measurement comes from red-shift and Hubble's Law. Measurements of the light from distant galaxy show a shift towards the red end of the spectrum. The Doppler equation allows the recessional velocity and, using $v = Hd$, the distance can be calculated. These two values are not compatible. Essentially, high red shift supernovae are fainter than they should be. This is interpreted as evidence for an accelerating Universe. The controversy is that there is no known mechanism driving this acceleration – which is why cosmologists are using ideas such as dark energy to try to account for it.

Some candidates were able to describe the two methods of measurement, their incompatibility and the controversial nature of theories needed to explain the accelerating Universe, using correct spelling, punctuation and grammar and the correct scientific terms. Candidates who did this obtained full credit. It was common to see answers which only described one measurement or simply described what supernovae were. Very poor answers suggested that measurements of distance and velocity were made of the same supernova over a period of time and that this resulted in acceleration. Similar poor answers implied that Hubble's Law is an indication of acceleration, as more distant objects are moving faster.

The inclusion of these ideas on the specification give students an opportunity to look into aspects of cosmology which are at the forefront of our understanding of how the Universe works. Questions on this, however, are likely to be limited to the ideas discussed in this report.

Part (b)(i) was one of the most accessible on the paper. The common difficulty for those who did not obtain full marks was due to a difference in units for the velocity of the galaxy and the velocity of light.

Part (b)(ii) was also very accessible. Again the most common error was with the unit of velocity. Having changed it to $m\,s^{-1}$ for part (i), several candidates did not use the correct unit for Hubble's Law. This usually resulted in candidates not gaining one of the available marks.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results statistics page of the AQA Website.