A-LEVEL
PHYSICS A

PHA5A – Astrophysics
Report on the Examination

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Section A – Nuclear and Thermal Physics

Question 1

Most students understood the questions about the range and dangers of ionising radiations but many failed to gain marks over the details. Part (a) was done well by a majority of students but in part (b)(i) there was a great deal of uncertainty about the range of alpha and beta particles. It was common to see alpha particles having ranges over 10 cm. However, almost all students did put the range of beta particles larger than alpha particles. Part (b)(ii) was done very well with a majority of students referring to the inverse square relationship between intensity and distance. A few did contradict themselves by quoting the inverse square relationship but then they talked about the intensity falling off exponentially. The other successful students discussed the spreading of the rays. Part (c) was again done well. Most realised that the dust had the potential to be ingested usually by breathing it in. Some students did struggle with the mark on the dangers of the ionising radiation. Some gave details of the damage that may be caused but failed to say that the damage is caused by the ionisation. Others did not explicitly say humans might be harmed or damaged, they simply said ionisation could occur in the body.

Question 2

The calculations involving the nuclear radius were done well but the question parts on alpha particle scattering were not answered as well as expected. In part (a)(i) a majority did refer to electrostatic or electromagnetic repulsion. There were however a significant number who chose to give the strong nuclear force or to simply refer to like changes repel. Interestingly there seemed to be a number of students, judging from their answers', who did not really understand the word 'interaction'. The response to (a)(i) was very polarised. Around half of the students understood that the charge of the nucleus did not change and neither did the scattering. The other half regarded the alpha particle as bouncing physically from the nucleus and therefore the radius or the change in nuclear size would have consequences. If contact had been made between the alpha particle and the nucleus the SNF would have put a stop to the scattering. In (b)(i) a majority of students had no problem in using the graph of Figure I. There were a handful who only showed the equation without any working data. A few others incorrectly thought that the gradient of the graph could give the value of the constant. This last group should be distinguished from a number of students who linearised the data before they found a gradient ie the gradient of R against $A^{1/3}$. The main stumbling block for some in (b)(ii) was to not actually perform the calculation which they set up. They simply quoted the radius given in the question. Students found the calculation required very easy. The calculation of the last part (c) was done well by a majority. A very small number quoted the wrong units and a few made errors in the volume calculation by either quoting the wrong formula for the volume of a sphere or getting the powers of 10 wrong in the calculation.

Question 3

This question was quite discriminating overall because of its synoptic nature and other mixed components. A majority of students got part (a) correct without too much difficulty. Those that did not, either missed off the antineutrino or they thought this stage of the decay was initiated by a neutron. Most students could perform the calculations required in part (b)(i). Most found the half-life and progressed from there. A significant number of successful students substituted data from the graph of Figure 2 into a decay equation. Most of the students who succeeded in (b)(i) also succeeded in (b)(ii). The most common mistake was to leave out the power of 10 from the activity reading from the graph. Part (c)(i) caused students a number of problems. Many spent too much time saying what a chain reaction was in very general terms without reference to the specific situation. Many scripts started, 'A chain reaction is when a process does something that creates an item that is needed for another process to take place...' Usually this was given in a much more verbose fashion. When it did come down to the specifics students were not very careful about using the correct terms. Although not penalised here a majority who mentioned uranium used the 238 rather than the 235 isotope. It was also common to see words like react or decay being used where fission should have been used. Also when a single stage of the process had been written down the next stage was not explained in sufficient detail. The words, 'and so on' came far too early. In (c)(i) it was only the stronger students who knew the part played by the critical mass. These students tended to gain both marks available for this part question because they knew how it had an effect on the chain reaction. The majority of the other students thought the mass had something to do with the mass of individual nuclei and its effect on an individual fission process. The final part (c)(iii) was done poorly by all but the most able students. Most thought that the ionisation caused by radiation made atoms radioactively unstable. Very few were aware of the problems caused by exposure to a flux of neutrons.

Question 4

This question was performed well by a majority of students. The explanation of a specific heat capacity in part (a) was very straightforward. The calculation in part (b) was done well by all but the weakest students even though it contained parts dealing with both specific heat capacity and latent heat. It was in choosing an incorrect number of significant figures that students lost the most marks.

Question 5

As in previous questions students found explanations difficult but this time they also found some of the calculations difficult. In part (a), the Quality of Written Communication question, it was surprising to come across so many students who appeared to have no knowledge of any experiment concerning gases. This became apparent when their potential experiment was considered. Some thought it feasible to measure the speed of molecules as the temperature was reduced. Others thought that the temperature would reduce uniformly as the pressure was reduced, even reaching absolute zero. A few latched onto an equation such as specific heat that involved temperature and thought they could substitute measured data when the temperature was equal to zero. These students were not an isolated few. Almost a third tackled the experiment in a way that would not work or be impossible to perform. Even students who used a workable idea thought that the experiment could be continued and actually reach absolute zero. The more able students did find this a straightforward task and gave the necessary details in a logical manner but the majority of students did not give their description in a clear fashion and their answers seemed to change direction many times. A very simple error made by many was to quote the temperature of absolute zero as -273 K. The question about assumptions, part (b)(i) was not read carefully by a number of students. In particular they did not respond to the emboldened 'movement' in the question. So many answers given were from the usual list of assumptions but they were not given credit here. An example being, 'molecules have negligible volume'. Even the stronger students sometimes got caught out in this way. As in previous exams some students mistakenly thought that random motion and Brownian motion are one and the same. The calculation of (b)(ii) was not done well by a majority of students. Not because of poor arithmetic but because students did not understand the processing of the term 'mean square speed'. Some students also had difficulties in part (c) with substituting data into the kinetic ideal gas equation. A large number of students squared the number given in the question for the mean square speed before making the substitution.

Section B – Astrophysics

General Comments

The Astrophysics paper gave students the opportunity to demonstrate their knowledge and understanding across a range of topics, and marks were achieved across the whole mark range. There was no evidence to suggest that students had insufficient time. The paper consisted of a range of calculation questions, diagrams and questions requiring short answers or extended writing.

Many students found the paper to be less demanding than last year. There was much evidence to suggest that students were quite well prepared, particularly for the more mathematical areas of the course.

There are many different units of distance used in astrophysics. Many of the answers seen suggest that students need to be much clearer about what they mean, when they are used and how to convert between them.

Question 1

The conversion from AU to metres was correctly carried out by most of the students and this gained them the first mark. A lot fewer students added the 1AU to account for the Earth's orbit, however. The calculation of the subtended angle was carried out successfully by the majority of students. It should be noted that, when a question asks students to "show that" a quantity has a certain value, examiners expect to see evidence of the final calculation. This can be achieved if students write their answer to one more significant figure than the value given.

The ray diagram of the Cassegrain telescope was drawn correctly by the majority of students. Common errors included: the wrong curvature on the secondary mirror; the curvature of the primary mirror making it look like two mirrors rather than one; the rays crossing before reaching the secondary mirror; the rays bending as they leave through the hole in the primary mirror. In the best answers, students drew the primary as one curve with a small gap in its centre, the rays crossed in this gap as they left the telescope and they used a ruler to help draw the rays. The calculation of the diameter proved to be more demanding. Students commonly used the wrong wavelength, or failed to give their answer the 2 significant figures suggested in the data.

In 1(c) students were expected to compare the two values of the angle in 1aii and 1bii. Although many could correctly state that, as the angle subtended by Vesta is larger than the resolution of the telescope, the surface of Vesta could be resolved, fewer went on to discuss what this meant in terms of detail. The best answers stated that details down to about one tenth the diameter of Vesta, or about 50 km, may be resolvable.

Question 2

Question 2(a) gave students an opportunity to show what they know about eclipsing binary stars and the full range of marks were awarded. At the highest level, answers were seen that correctly described how the motion of the two stars gives rise to each graph, with calculations of the time period, orbital speed and, in some cases, orbital radius. Some students incorrectly suggested that the change in apparent magnitude was due to changing distances, rather than one star blocking the other. There was some confusion with students suggesting that low apparent magnitudes means dimmer, and the time period was incorrectly given as 2 days, or 8 days, in some answers. Some students also confused the Doppler shift of the second graph with cosmological red shift and suggested using Hubble's Law to determine the distance to the binary system. The guidance booklet for astrophysics, available on the AQA website, includes an analysis of a binary system that may be helpful to teachers and students unfamiliar with this area.

Many students correctly identified the stars as class A, but fewer went on to say that these stars would have strong Hydrogen Balmer lines and therefore make measurement easier.
Many students are clearly well practised in the use of the magnitude-distance equation. Some were confused about the unit of distance to use in the equation, however, and some had difficulty determining the value of the apparent magnitude when the system was dimmest.

Question 3

A range of values were acceptable for the wavelength of the peak in the intensity curve. Many students, however, chose the value on the curve where the wavelength is greatest. This was treated as a physics error and the first two marks were not awarded. The vast majority of students gave the correct unit for temperature. Occasionally ^{o}K was seen and this was not accepted. It should also be noted that the unit is K (or kelvin) and not k. On this occasion, benefit of the doubt was given when it was unclear.

Any error in the temperature was carried forward into 3(a)(ii) allowing full marks to be given. Problems here were mainly due to the incorrect area equation. It was common to see the volume of a sphere, or the area of a circle, used. Many students also failed to use the fourth power of the temperature, even after writing it correctly in the formula.

3(b)(i) was automarked and only dwarf star was accepted as the answer.

The error in 3bi was carried forward into 3(b)(ii), so that full marks could be given if the student's answer was consistent with their answer to 3(b)(i). The best answers made it clear how the radius and temperature of the star supported their answer to 3(b)(i).

Question 4

On this specification, the defining property of a black hole is that it has an escape velocity greater than the speed of light. References to singularities were ignored.

The calculation of the radius of the event horizon was the most accessible question on the paper, with 84% of students getting both marks.

The calculation of the age of the Universe caused more problems for some students. Many gained full marks by simply converting the distance into metres and dividing it by the speed, removing the need to calculate Hubble's constant and convert the units into seconds.

Mark Ranges and Award of Grades

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

Converting Marks into UMS marks

Convert raw marks into Uniform Mark Scale (UMS) marks by using the link below.

UMS conversion calculator www.aqa.org.uk/umsconversion