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General Certificate of Education (A-level)
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Physics A PHYA1

(Specification 2450)

Unit 1: Particles, quantum phenomena and electricity

Report on the Examination

General Comments

The paper gave candidates the opportunity to apply their knowledge and understanding across a range of topics covered by the unit. It was clear that in the majority of cases they had benefitted from careful preparation although some aspects of the paper did prove quite challenging and this was particularly noticeable in the questions on electricity.

It was clear that a significant proportion of candidates were unfamiliar with the term "ohmic conductor" and evidence for this can be found in the marks achieved in the question where candidates had to describe an experiment to test whether a component was ohmic or not. Candidates also had great difficulty analysing the parallel circuit in question 6 with half of them failing to deduce any of the potential differences required in part (b). They also found the qualitative aspect of the question challenging with only 21% scoring full marks in (c)(i) and 14% scoring full marks in (c)(ii).

The other topic that seems to have given the candidates difficulty was the explanation of excitation of the hydrogen atom by electron collision and it was relatively common for candidates to confuse this process with excitation by the absorption of a photon. To balance this, candidates did very well in the question on atomic structure with full marks being relatively common. Presentation was good, and there continues to be fewer examples of answers exceeding the allotted space. The dedicated marks for units and significant figures did not present students with too many problems. Students usually showed full working for calculations and this seemed to help them arrive at the correct answer or allowed for consequential error marks to be awarded in subsequent calculations.

Question 1

This question was concerned with atomic structure and radioactive decay. The majority of candidates did not really have any problems with part (a) which required them to identify the constituents of the atom and state which had the largest specific charge.

The performance in part (b) was not quite as strong although only 25% of candidates had real issues with the equation for beta decay. The weakest answers were seen in (b) (iii) which required a specific charge calculation. Questions on this topic tend to be quite discriminating and this was certainly the case this time. Common mistakes were the use of incorrect masses for the technetium nucleus and dividing the mass by the charge rather than the charge by the mass. The unit for specific charge seemed to be well known although a significant minority gave the incorrect answer: coulomb.

Question 2

This question required an understanding of the mechanism of pair production and whilst the majority of candidates were able to name the process, a significant number of them were unclear of the details. This was particular noticeable in part (b) where candidates were required to calculate the minimum energy required to create an electron positron pair. Only about 27% of candidates managed to do this successfully. The most common error was a failure to convert the rest mass of the electron and positron into joules. Some candidates did use the masses of the particles and Einstein's mass energy equivalence equation to determine the frequency. This is of course perfectly acceptable even though the equation is in unit 5. This calculation required an answer to an appropriate number of significant figures and as this was a stand-alone mark, many candidates were awarded it even though their frequency was incorrect.

Part (c) generated some good answers although about a third of candidates did not appreciate that higher frequency photons would result in the electron and positron having more kinetic energy. In part (d) many candidates realised that the positron would annihilate but over half thought that this due to the positron meeting the original electron.

Question 3

Part (a) of this question required candidates to understand the classification and quark structure of hadrons. This proved to be very accessible and well over 90% of candidates were able to state how many quarks there were in a baryon and were also familiar with mesons. When it came to properties of hadrons the majority were able to state one property but only about half were able to come up with two properties. A common error was to state the same property twice, an example of this being: hadrons interact by the strong interaction and leptons interact with the weak interaction. It was also quite common to see answers that referred to baryon numbers and this was not an acceptable answer as hadrons do not all have the same baryon number.

In part (b) candidates were required to identify the exchange particle in two interactions. A high proportion of candidates were able to identify one of these but only about half were able to give two correct exchange particles. Many lost marks with the weak interaction exchange particle by omitting the relevant charge (W^+ or W^-).

Part (c) was concerned with electron capture and this was a topic that had also come up in the June 2012 paper. Candidates were required to draw a Feynman Diagram that represented electron capture. Full marks for this were comparatively rare and common errors were the omission of arrows on the lines representing the proton, the electron, the neutron and the neutrino or the omission of an arrow on the exchange particle. The latter was only penalised if the candidates showed the exchange particle horizontally (when an arrow pointing in the correct direction was required). The final part of this question on lepton conservation was well answered. The only consistent error seen was when less able candidates tried to explain this in terms of charge conservation.

Question 4

This question required candidates to be familiar with discrete energy levels and excitation by electron collision. This is a topic which has caused problems in the past and it is clear that the ideas involved continue to trouble candidates.

In part (a) they were required to explain the process of excitation and less than 20% of candidates were awarded full marks for their answers. Many were able to explain the energy transfer that took place between the electrons but very few were able to explain convincingly that an exact amount of energy had to be transferred. It was also quite common to see answers referring to excitation due to photon absorption rather than electron collision. In part (a) (ii) candidates were required to calculate the frequency of the photon emitted when an electron drops to the ground state. This was generally done well although nearly a third of candidates failed to convert the energy in electron volts to joules and were therefore limited to one mark. The remaining parts of (a) were concerned with the energy of the incident electron. This question proved to be quite discriminating and only the stronger candidates managed to score full marks.

Part (b) also turned out to be very discriminating and only about half of candidates were able to explain why hydrogen atoms, whose electrons had been excited to level 3, were able to emit photons of three different frequencies.

Question 5

In this question candidates needed to understand what is meant by an ohmic conductor and to describe an experiment to determine whether a particular component exhibited the necessary properties to be classed as this type of conductor. A significant proportion of candidates could not state what is meant by an ohmic conductor and responses such as "obeys Ohm's Law" and "something with resistance" were quite common.

A high proportion of correct circuit diagrams were seen in part (b)(i) and incorrectly placed voltmeters were rare. The main omission was a means of varying the current in the circuit. The experimental design caused problems and less than 15% of candidates wrote answers that qualified them for the top band. Some described the wrong experiment such as investigating the effect of temperature on the resistance of a thermistor. Those that did describe a correct experiment tended not to fully develop their answer. It was expected that a top band answer would have details of how a graph of results might be interpreted and in many cases this was only done in a very superficial manner. Candidates who did refer to a straight line indicating direct proportion often failed to mention that for this to be true the line must go through the origin. There was also a tendency for them to state that the gradient of the graph is equal to the resistance. While this is true for a straight line graph going through the origin, it is not generally true and it was clear from a significant proportion of responses that candidates are not aware of this. It was good to see evidence of candidates planning their answers and given that they find these types of questions a challenge, this is a practice to be encouraged.

The remaining part of the question required knowledge of superconductors and although a high proportion of candidates failed to give a convincing use of superconductors the important property of a superconductor and the significance of critical temperature proved to be well understood.

Question 6

In this question candidates were required to analyse a bridge network of resistors. The calculation of the circuit resistance in part (a) proved to be reasonably straightforward with over two thirds of candidates scoring full marks. The only common error in weaker scripts was the combining of all the resistors as parallel resistors instead of combining the series branches first. The calculation of current in part (a) (ii) was done well and with consequential error applied, the majority of candidates were able to do this successfully.

Part (b) was not well answered and very few candidates were able to give correct answers for the voltmeter reading in the three positions. The position that proved the most challenging was the pd between C and D and it is clear that many candidates did not appreciate that this was found by subtracting the pd across D and F from the pd across C and E.

Part (c) was a qualitative question and previous papers suggest that candidates find these difficult. Only the very best candidates managed to get full marks in this section and it was the explanations of the effect on the voltmeter that proved to be the most challenging. For example over 60% of candidates appreciated that the pd across the thermistor decreased but only about 14% managed to explain why. A common mistake was to try and use current in explanations and this led them to conclude incorrectly that if current goes up then so does pd or that the increase in current cancels out the decrease in resistance. Very few used the constant 12 V across the parallel branches to justify their conclusions.

Question 7

The first part of this question involved the use of the resistivity formula and many were able to do this successfully. In the vast majority of cases they were also able to calculate the current flowing in the lamp using the power formula.

Parts (b)(ii) and (iii) were answered less successfully and only about half of the candidates appreciated that the pd across the wires was found by multiplying their answer in part (a) by the answer in part (b)(i). In part (b)(iii) candidates were required to calculate the emf of the supply and this proved to be quite a challenge with only about 23% scripts obtaining full marks. Many answers gave values of less than 12 V.

Part (c) required a knowledge of the effects of internal resistance and this is a topic that has caused problems in the past. This time however, fewer confused answers were seen and full marks were relatively common.

Mark Ranges and Award of Grades

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