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Specification A

PA01 Particles, Radiation and Quantum Phenomena

Report on the Examination

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General Comments

The paper was a good discriminator and a full spread of marks were seen. There was a significant tail in the distribution of marks, which showed many candidates had not adequately prepared themselves for the examination, for example, losing marks by not giving the units to answers to numerical questions. Some candidates had not completed the unit specification. The paper on the whole was slightly more difficult than some previous papers because fewer questions had help or clues. For example, units were not given in questions and the Feynman diagram was not partially started. Even so, a good number of candidates obtained scores over 90%, with a handful scoring 100%.

Question 1

Good candidates picked up full marks but many candidates made some sort of error, the most common being to leave out units in part (c). For the less able candidates, even asking for the number of neutrons proved to be difficult.

Question 2

Full marks were obtained by many candidates. However, less able candidates just wrote about the de Broglie relationship without answering the question. Others wrote about electrons being like waves. Some even thought that the photon was an electron when acting like a wave.

Question 3

This question was surprisingly discriminating. In part (a) (i), incorrect answers of conservation of charge and strangeness were often seen. Most candidates could write the correct equation representing positron emission. Only a minority of candidates gained full marks in part (b). The requirement to show the Feynman diagram using quarks rather than nucleons proved to be difficult and many simply ignored this part of the question. The other difficulty arose because the diagram was not partially started. Many candidates did not give a diagram showing a definite direction in which time was moving forward. Some candidates gave the impression that they had never drawn a Feynman diagram before.

Question 4

The marks were spread in part (a). Less able candidates lost the first mark by referring to the minimum energy rather than the minimum frequency. Following this, few scored on the second mark, which required reference to three items, a metal, ejected electrons and electromagnetic radiation. The graph was drawn well by many and the position of the threshold frequency was known by a majority. Some candidates incorrectly drew curves from an intercept on the frequency axis. A majority of candidates started part (b) well and calculated the threshold frequency. The maximum kinetic energy was again calculated correctly by half of the candidates. Apart from the less able candidates, who made no attempt, others failed to substitute the correct data into Einstein's photoelectric equation correctly. Many wanted to use the threshold frequency as the incoming electromagnetic frequency. About 50% of candidates answered part (b) (ii) correctly. The incorrect answers often appeared to be guesses.

Question 5

Part (a) was quite straightforward but it was not answered well by many candidates. Most completely ignored the aspect of the question that separated the similarities from the differences between excitation and ionisation. Candidates simply wrote what they could about both of these processes. Many used phrases that could be interpreted to mean electrons go to various energy levels at an intermediate stage in ionisation. The conversion between joules and electron volts was done well in part (b), but the arrow showing the transition on the diagram was drawn in the wrong place or less able candidates had the arrow pointing in the wrong direction. In part (c) (i), only the more able candidates had the confidence to say the electron stays in the ground state as it does not have sufficient energy available to reach even the next level up. Few candidates stated that the photon must have the exact energy, corresponding to the energy of promotion of an electron to another state. In part (c) (ii), a majority of candidates realised that an electron was released from the atom but there was confusion as to what happens to the excess energy. Some thought it stayed with the photon after causing ionisation. Some scripts also suggested that ionisation occurred at the sixth energy level.

Question 6

The calculation in part (a) was performed well by a majority of candidates but some candidates lost marks through unit errors. The ray diagram caused problems for many. As the ray entered the air, the ray was drawn changing direction, towards the normal, by about 20% of the candidates. Of those who drew the refraction correctly, many did not realise that the second ray hit the boundary at the critical angle. On a more positive note, more candidates than usual used a ruler and drew normals. Part (c) was difficult. It was necessary to discuss the change in the relative refractive index at the boundary, which was reduced, to obtain the explanatory mark. Many candidates simply wrote about the critical angle for oil alone. It was appreciated that the candidates would not know if the refractive index for oil is larger or smaller than water. It was possible to gain full marks either way. A smaller refractive index for oil leads to a larger critical angle because the relative refractive index at the boundary is less. A larger refractive index for oil leads to a bending of the light towards the normal and no total internal reflection is possible.

Mark Ranges and Award of Grades

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