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General Certificate of Education

Physics 2456

Specification B: Physics in Context

PHYB5 Energy under the Microscope

Report on the Examination

2010 examination - June series

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GCE Physics, Specification B: Physics in Context, PHYB5, Energy under the Microscope

General Comments

This paper challenged students across a wide range of topics and skills. It was very encouraging that many candidates demonstrated a high level of knowledge and understanding of physics and the ability to cope with the wide variety of questions under the time constraints of the examination. There were some outstanding performances from the more able candidates who were able to apply their knowledge and understanding consistently across the full range of topics tested. The questions that proved to be the most difficult in which to score marks was question 6. In general, the understanding of capacitors demonstrate by the majority of the candidates was disappointingly poor.

Answers were usually well presented but there were some candidates whose presentation presented problems when trying to assess the worth of an answer. This was especially the case for those who wrote using letters so small that word endings often disappeared and became indecipherable even when magnified. The processes used in calculation questions were easy to follow for the vast majority of the candidates and explanations were usually well constructed grammatically though not always relevant.

Question 1

There were many good responses to part (a), although many did not refer to identify the ‘per kg or per unit mass’ aspect of the definition.

Many did not take account of the 20% factor in part (b) (i) but were able to determine the energy using $mc\Delta\theta$. Giving an appropriate unit proved too much for many especially those who worked with the energy in kJ.

Many correctly determined the total input power in part (b) (ii) and assumed this to be the answer. Many candidates worked with 20% instead of 25%. A common incorrect response was 0.25 × 280 = 70 kJ.

There were many very good answers to part (b) (iii). Some did not identify the efficiency formula in their answers. Qualitative answers in terms of entropy change were rare.

Question 2

Most candidates were successful in part (a) (i) and most who obtained Z and A correctly identified the neutron.

In part (a) (ii) a majority appreciated the repulsive force but some did not explain why it existed. There was a significant proportion that referred to the repulsive force as the ‘strong force’.

Units were a problem in part (a) (iii) for many candidates. Candidates, variously, calculated a decay constant in s^{-1}, minutes^{-1} or h^{-1}. In the decay formula, however, the activity was given, for example, in s^{-1} whilst the time was in h. Many substituted 20 GBq for A_0.

There were many correct responses to part (a) (iv) and the majority of the candidates appreciated that the decay constant had to be in s^{-1} in this calculation. An incorrect power for ‘G’ was a common error.

There were many good clear responses to part (b) (i). There was however a significant proportion who identified correctly the relevant formulae but were unable to eliminate *v.*

Part (b) (ii) was a straightforward substitution in a given formula requiring only the identification of the mass and charge of the proton. Some candidates used the mass of an electron, others failed to square the value for charge correctly or used 1.8 as the radius. The unit was not as well known as one would expect at this level.

Question 3

In part (a) (i), the more able candidates appreciated that the half-thickness should be the same from any starting value. Others used ratios other than halving or compared values of μ for different thicknesses. Calculating a value of μ and using this to calculate a value after another thickness and comparing it with the graph value was also popular. A definite conclusion was expected.

Some were stumped by the fact that the graph (intentionally) did not include two or more half-thicknesses. This question was designed to test appreciation of different approaches from that often met in 'half-life' questions where successive 'half-lives' are used in the proof. As a result some candidates quoted one half-thickness and then gave a value that would be expected after another which proved nothing.

Part (a) (ii) was usually done well. A minority wrote about 'half the thickness of the absorber required to…'.

The material or density was usually given in part (a) (iii) but relatively few appreciated the dependence on the photon energy. The half-thickness concept refers to gamma radiation or X–radiation so mention of the type of radiation was not relevant.

The numerical value was found correctly by most candidates in part (a) (iv) but fewer appreciated that the unit would be the reciprocal of a length.

In part (b), many candidates correctly described the change to the intensity expected for a doubling of distance from a source. Fewer described using a thickness equal to twice the half-thickness affected the intensity of the radiation or explained that knowing the half thickness would enable the intensity to be calculated for a given absorber thickness of the calculation of a suitable thickness to use.

There were many misunderstandings apparent. Some candidates implied that absorber thicknesses could only be used in multiples of half thickness. Others stated that if a material with a greater half thickness were used then more radiation would be absorbed and therefore provide better protection, without reference to the actual thickness of absorber being used.

Question 4

A majority of the candidates was able to give an advantage or disadvantage in part (a) but only a quarter gave acceptable responses to both. Vague reference to greater size or area was not accepted.

Part (b) (i) was done well. Some candidates lost the mark for not giving the equation they were using.

A majority of the candidates completed part (b) (ii) successfully.

The most common error in part (b) (iii) was to give the relativistic mass as the answer and not the **increase** in mass as required. A significant proportion of the candidates quoted the correct formula but did not substitute correctly or did not correctly calculate the squared quantities in the denominator.

Even with a generous marking scheme fewer than half the candidates were able to provide a relevant reason for a reduction in length in part (b) (iv). The issue here was the energy supplied during the acceleration manifesting itself as an increase in mass rather than speed so that having arrived a the drift tube particles would be travelling slower than that determined by ignoring relativistic increases in mass. Some candidates were clearly of the view that particles are being accelerated in the drift tubes stating that due to the increase in mass particles would have lower acceleration so the drift tubes would need to be longer.

Question 5

That there are no external factors influencing the decay was well known in part (a) (i).

Part (a) (ii) was done well. Most were able to calculate the mass change in u but many did not convert this to kg when using $E = \Delta m c^2$.

There were many lengthy responses to part (a) (iii) that were written fluently but which were superficial and contained little physics to address the issues in the question. There were some good responses but most provided inadequate detail to achieve the highest level. Candidates often showed appreciation of the use of thermocouples and thermopiles but there were many who misunderstood the structure and operation of a thermocouple. Some suggested unrealistic methods decided that the alpha source would be suitable to heat water which is used to produce steam which drives a mini-turbine and mini-generator. When discussing the risks, many responses said no or little more than 'radiation might leak which is dangerous'. Some discussion of why radiation is dangerous was expected.

Most candidates made some progress with part (b) (i), identifying the correct equation for force but only a quarter of the candidates was completely successful. A significant number did not include the square of the separation when doing the substitution after having quoted the correct formula and arithmetic many could not identify the charges that were needed, 90 × 2 and $(1.6 \times 10^{-19})^2$ being common.

Allowing the error carried forward many candidates were successful in part (b) (ii).

Most showed some appreciation of the process in part (c) (i) but many candidates did not make any reference to a nucleus in their answers. A significant proportion stated that a single neutron was released when the nucleus splits causing a chain reaction.

Over half the candidates were able to successfully complete part (c) (ii). Many were unable to determine the correct amount, in mol, of uranium, 0.5/235 being common. Having found the amount in mol, many did not proceed to find the number of nuclei in 0.5 kg but simply multiplied the amount in mol by the energy released in the fission of one uranium nucleus.

Question 6

Candidates were penalised heavily for poor technique in this part (a) (i). It was expected that, at this level candidates, would draw a tangent to the curve and not simply read off coordinates in the first few small squares of the graph to find the initial rate of change of charge. Some who appreciated that a tangent would be useful drew one in the wrong place.

Most candidates used the $V = IR$ approach in part (a) (ii). Some candidates incorporated the 510 Ω heart resistance into the resistance of the charging circuit.

Part (a) (iii) was not done well and very few candidates gave completely convincing arguments and many who seem to have no idea where to start. There were many candidates who wrote about charge build up on the capacitor increasing the resistance of the capacitor. Others appreciating the rise in pd as charge accumulates on the capacitor stated that this reduced the emf of the supply. Appreciation of the reduction in the pd across the resistor as the pd across the capacitor increases was rare. Arguments such as ‘charge accumulating repels other charges’ gained some credit. There was a significant proportion who wrote that as charge builds up there is less *space* on the capacitor for more charge or that because charge has been added to the capacitor there is less available in the circuit to provide further charge.

A surprising number failed to obtain the correct answer to part (b) (i). Many used ½ QV or ½ CV^2 assuming V to be the value of the emf that had been calculated in (a) (ii).

Those who failed to obtain 14000 W in part (b) (ii) usually failed because of problems with powers of 10.

Only the more able candidates made progress with part (c). Most of these obtained the time constant correctly. Fewer went on to determine the charge after 8.3 s using the graph and to compare this with 85 mC required or to state that the graph showed that about 10.5 s was needed to achieve the 85 mC. There was a small minority of candidates who showed that the energy stored would be insufficient after 8.3 s although this was not necessary.

Question 7

In part (a) (i), the term *moderator* was known by just over half the candidates.

Only 25% of the candidates obtained the correct answer to part (a) (ii). Most only subtracted 0.025 eV from 1 MeV so calculating the energy lost in all the collisions whereas the questions required asked for the average energy lost in each one of the 100 collisions which it took to lose this energy.

In part (a) (iii), the consequences of a head on collision between two (approximately) equal masses was generally well known.

For part (b), many quoted 3/2(kT) in an equation but few were able to make use of it convincingly. The energy could be calculated from ½ m^2 or eV. Most who made progress used the latter approach but a common error was failure to convert 0.025 eV to J.

Candidates found part (c) (i) hard to explain. Diagrams were often drawn so badly as to be unhelpful. It was not always made clear that the term is related to colliding or interacting particles. Although ‘area’ was often mentioned it was not always clear what this area was.

Answers often mixed up areas with distances, so expressions such as 'an area of 2*r*' or 'an area equal to the diameter' were not uncommon.

About a third of the candidates knew that the 'barn' was the unit used in part (c)(ii). Many provided 'invented' names for the unit.

Mark Ranges and Award of Grades

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