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**General Certificate of Education (A-level)**
**June 2011**

# Physics B: Physics in Context PHYB5

## (Specification 2455)

## Unit 5: Energy under the microscope

# *Report on the Examination*

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

**General Comments**

The most able candidates were able to complete this paper to a very high standard and even the less able candidates were usually able to make some headway with all questions. Few candidates did not attempt the vast majority of the parts of each question, but answers were frequently ambiguous and imprecise. Presentation was variable with some very neat and easily followed scripts offset by several in which answers were untidily presented and very difficult to follow. It is essential in 'show that' questions every step of an argument is made clear and that equations are written down as the first step – too frequently, this was not the case. When handwriting is unreadable, examiners cannot give candidates the benefit of the doubt – again, this too frequently occurred.

**Question 1**

In part (a), most candidates showed a reasonable understanding of the thermodynamic processes involved, although the terms in the first law of thermodynamics were frequently not clearly explained. There was some degree of confusion between working, internal energy and heat transferred.

Most candidates gained a high mark in part (b)(i). Some could have made it clearer as to which equations they were using and several expressed the stages in the calculation in an illogical manner.

Part (b)(ii) was found to be more challenging and a significant number of candidates did not see any of the routes to the solution.

Many candidates forgot to convert temperatures to K in part (b)(iii) and dividing the heat by the difference in temperatures was very common. Most gained the unit mark although $C\,s^{-1}$ was an occasional incorrect alternative.

For part (b)(iv), most candidates recognised that the overall entropy change would be an increase. Some clearly focused on the 'system' and said that it had decreased but did not go on to explain that that of the surrounding had increased by a greater amount meaning an overall increase in entropy.

**Question 2**

Most candidates were able to make a good attempt at part (a), explaining the meaning of 'meta stable'.

A significant number of candidates had a good appreciation of what needed to be done in the calculation to part (b)(i) – of these a high proportion spent time converting times etc into seconds, when working in hours would have been more straightforward. A high proportion of candidates left the examiners to interpret the final conclusion. Less able candidates argued that after 3 half lives 12.5% of the material remained therefore 87.5% had decayed meaning that after 3.3 half lives approximately 10% would be left.

Most candidates gained all three marks in part (b)(ii). A minority either forgot to convert keV to J or else calculated the frequency rather than the wavelength. A significant minority believed that $f = 1/\lambda$.

Few candidates gave answers specific enough to allow them credit in part (b)(iii) – most simply giving standard gamma radiation properties such as poor ionization and low level of interaction with matter. The gammas emitted in this case are of high initial activity with many photons per second and the frequency is equivalent to many X-rays so use of X-ray detection techniques is appropriate.

As with the previous part, answers to part (b)(iv) tended to be rather vague. Most candidates did not recognise that a low half-life means a high initial activity leading to high gamma photon flux needed for imaging. Answers relating to the very low ionising power of gammas often did not go on to say that this meant that tissue cells would be unharmed. A minority of candidates mentioned that the biological half-life of the beta emitter would be much less than its physical half-life and thus the dose would soon be excreted by the patient's body.

The vast majority of candidates completed the balance nuclear equation in part (c), however significant minorities either included multiple terms on the left hand side of the equation or missed out proton numbers of the nuclides. Most candidates correctly included an antineutrino.

**Question 3**

In part (a)(i), most candidates understood that the protons accelerate in the gaps and move with constant velocity inside the drift tube. There was often confusion about what causes the acceleration – few mentioned the electric field across the gap and references to the tubes being charged where often confusing. With no charges in the gaps and or inside the cylinders, positively charged cylinders repelling protons and negatively charged cylinders attracting electrons is inaccurate and misleading. Other candidates stated that it was a magnetic field which accelerated the protons.

Part (a)(ii) was generally answered very well.

For part (b)(i), most candidates equated *Ee* to ½ $mv^2$ but many forgot to include the factor of 24 corresponding to the number of times the protons are accelerated. Use of 25 was a common mistake.

Substitution into the formula for $\gamma$ was common in part (b)(ii) but many candidates did not square the *v/c* factor. Having seen that the factor made negligible difference to mass, many went on to say that the relativistic correction was necessary.

**Question 4**

In part (a)(i), most candidates shaded the region around the deflection tube. Many included the velocity selector region, which was allowed. Significant numbers showed the field encroaching beyond the deflection tube – this was not credited.

For part (a)(ii), only out of the (plane of the) page was allowed, with ‘up’ being too ambiguous to gain credit.

Part (b) was another generally well answered question, with many candidates gaining all four marks. Most equated the *BQv* to the centripetal force and concluded that radius of deflection is proportional to mass of isotope. Less able candidates often spotted that the isotope of mass 24*u* would be deflected the most but did not support their answers using the relevant equations.

Many candidates were unsure of what to do in part (c). Those finding the weighted average of the isotopes often spotted that the molar mass was simply the u value converted into kilograms. Other candidates went on to find the mass of one molecule and then multiplied by Avogadro’s number to obtain the molar mass; many however simply found the molecular mass of the 24u isotope.

Those candidates equating EQ to BQv usually gained the correct answer in part (d)(i), although a good number ended up with the wrong power of 10. A significant number either appeared not to have met the ‘crossed fields’ concept.

In part (d)(ii) a slight majority of candidates recognised that the speed is independent of charge but many focused their answers on just one of the fields and argued for changes.

Most candidates recognised that a larger charge meant a smaller radius of curvature in part (d)(iii) but only a minority actually stated that doubling the charge halved the radius of curvature.

**Question 5**

Although there were some very good explanations of *mass defect* and descriptions of the relationship between mass defect and nuclear binding energy many candidates gave very inconsistent and confused answers to part (a)(i). The terms molecule, atom, nucleus, nuclide, element and nucleons were frequently used interchangeably. Answers relating to parent and daughter products of radioactive decay were rarely successful.

Most candidates were able to read the binding energies from the graph within tolerance in part (a)(ii). Many then were able to find the difference between the binding energies of the four nucleons both for hydrogen and helium. A very significant number of candidates subtracted the binding energy of 2 hydrogen nucleons from 1 helium nucleon.

Part (a)(iii) was generally done well.

In part (a)(iv), the majority of candidates did not recognise that the total kinetic energy of the nuclei would be equal to the electrostatic potential energy when their centres were on nuclear diameter apart. Many tried to use ½ $mv^2$ and floundered; others calculated the force between the nuclei but could not make further progress.

Many candidates were unsure what a plasma is and this made it difficult for them to focus their answers to part (b). 'Sea of ions' was a common misconception. Most knew that a magnetic field was required to confine the plasma to the torus and many commented on the immediate cooling effect that touching the sides would produce. Although virtually all candidates mentioned the requirement of a high temperature, few could explain how heating came about. A number of candidates showed a misunderstanding of heat and temperature in this question. Given that the quality of written communication was being assessed in the question many candidates took little care over presenting their answers in clear, unambiguous, well-spelt English.

**Question 6**

In answer to part (a), many candidates simply said that a capacitor is used for storing charge/energy. Most were able to give a more formal definition, although mixing quantities and units was very common.

Most candidates simply described the graph in part (b)(i). Those candidates explaining the curve often did little more than to say that as the charge builds up on the capacitor it becomes more difficult to charge it further. Few candidates attempted to consider summing the potential differences and emf to support their explanation.

In part (b)(ii), The majority of candidates incorrectly drew the second curve below the one shown in **Figure 7**.

The majority of candidate wrongly believed that the capacitors would be connected in parallel in part (c)(i). A significant number of candidates attempted to describe the actual wiring of the capacitors to the ICD.

Many candidates chose to answer part (c)(ii) by calculating the charge from E= ½*QV* before calculating the capacitance. It was clear from the values of voltages used that many did not understand that they were dealing with the combination of capacitors rather than a single one of the capacitors.

Most candidates correctly did the calculation in part (c)(iii) but many were penalised for an incorrect or inconsistent power of ten or for giving an incorrect or inappropriate unit – the unit of time constant is second; this is dimensionally equivalent to ΩF but far more appropriate when talking about a time; thus, ΩF was not awarded credit.

Part (c)(iv) was generally done well, with most candidates making sensible substitutions for quantities into the decay equation. A large proportion of the candidates were penalised for quoting the final answer to one significant figure – such low precision is total inconsistent with the precision of all the data.

In part (d)(i), many candidates merely suggested that the capacitor would no longer work but few explained that this was because the insulator between the plates is made to conduct by the high voltage. Several candidates talked about explosions but that would only occur in an electrolytic capacitor which has been connected to supply the 'wrong way round'.

Most candidates gave a good example relating to the benefits of using ICDs in answer to part (d)(ii). There were many superficial and hypothetical suggestions relating to the design. Better answers usually related to the need for very-long life batteries and the need for materials that minimised rejection by the body.

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