Version 1.0

AQA

General Certificate of Education (A-level)
June 2012

Physics B: Physics in Context PHYB5

(Specification 2455)

Unit 5: Energy under the microscope

Report on the Examination

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

General Comments

There were some outstanding scripts in which students demonstrated a sound understanding of the principles and concepts in the specification. The responses of some students, however, conveyed only a superficial understanding of the ideas. This was particularly evident in explanations that often contained vague generalisations and little or no attempt to include physics that should have been familiar having followed the A level course. Students generally were more successful in calculations although many were unable to gain credit for partially correct attempts because working was not shown or was unclear. Those who could present a structured argument in a calculation invariably were able to gain some and often most of the marks even when their final answer was incorrect.

Question 1

In part (a)(i) there were many correct responses. Some students ticked three options or even all four suggesting that the concept of a cycle was unfamiliar to them. Part (a)(ii) was usually correct. The term' heat' alone was not accepted. This is vague and is often used by students when they should refer to internal energy or when they mean the process of heating. Part (a)(iii) was also well known. Some students gave U or stated 'internal energy' as being zero. Appreciating that it is the change in internal energy that is 0 was essential. Part (a)(iv) was not well done only about a fifth of the students appreciated that pV should be constant and few of these did not explain adequately the process for demonstrating this from data on the graph. Students needed to appreciate that the use of two points is not sufficient evidence as there are an infinite number of curves that could join two points and only for one will pV be constant for all points.

In part (b)(i) there were many correct answers. Weaker students tried using temperatures or ran into problems handling 2/5 and 3/5. The most common error in (b)(ii) was forgetting that there were 4 cylinders. Most students tried to apply $E = mc\vartheta$ but some thought that c was the speed of electromagnetic radiation and others used the specific heat capacity for E and 33 kW for c.

For part (c)(i) most students applied the formula for maximum efficiency although very few referred to this as such. Most used the temperatures correctly to arrive at 1/3 or 33%. Very few students stated that the quoted efficiency of 40% was impossible because it was higher than the maximum possible efficiency based on the temperatures (or that the temperatures were incorrect) and stated only that the efficiency quoted was different from 33% and therefore quoted incorrectly.

In part (c)(ii) there were few correct answers to this part. Answers that considered a single cylinder or 4 cylinders were allowed. Those who used correct energies and temperatures did not identify which was + an which – so ended up with 12 J K^{-1}. Many quoted $S=Q/T$ but did not know how to apply this. Some used the useful energy with one of the temperatures and others used either the source energy or the sink energy divided by the difference in temperatures. Most gained the mark for the unit. Some included s^{-1} which was not allowed (following the same principle, for example, that if asked for the distance travelled in 1 s by a moving object the answer would be m not m s^{-1}).

In part (c)(iii) allowing error carried forward many explanations were good in this part. Those who obtained a positive answer argued along the lines that there was nothing to suggest that the operation had been incorrectly reported since entropy had increased as expected.

Question 2

In part (a)(i) the emission of electrons from metal surfaces by heating was appreciated by many but explanations of the variation in speed were usually poor. Most students simply stated that the speeds were different because they had different kinetic energies. They needed to refer either to the electrons being supplied with different energies inside the metal or that they used more energy was used to release them from deeper inside the metal surface so the KE after emission would be lower. There were many who confused such emissions with ionisation. Part (a)(ii) was well done by most students.

In part (b)(i) there were many correct answers. Some gave the correct direction but explained only that they had applied the left hand rule. Some indication of the direction of the conventional current (to the 'left' or opposite to the direction of movement of the electrons) was expected.

In part (b)(ii) the method was appreciated by the majority of the students. There were an inexplicably large number of students who used 1.6×10^{-9}C for the charge on an electron. One can only suppose incorrect recall or careless reading of data on the data sheet.

In part (c)(i) there were a number of ways of tackling this. The most common was to determine or try to determine the relativistic increase in mass. Those who did not succeed with this usually had difficulty with the squares and square root when applying the formula. Many then divided this by the rest mass arriving at 1.0114. Some seeing a number about '1' thought that this was the percentage increase. The better students realised that this meant a 14% increase in mass. There was a significant number whose method led to them determining $(m\text{-}m_o)/m$. This led to the percentage change when decelerating the mass from the higher speed to rest which, although close, was not the same as the required answer.

For part (c)(ii) most appreciated that a higher pd was required and that the radius would be larger but explanations generally lacked rigour. Some only wrote in the first part, for example, that *Vαm.* Others quoted the full formula but then neglected to identify the constant quantities. There were some good explanations given that did not rely on quoting formulae.

Part (d)(i) was well done and there were many students who gained full credit. Weak explanations used phrases such as 'the electric force is opposite to the magnetic field' or that 'the fields cancel'. In part (d)(ii) there were many correct answers to this part. Students who were unsuccessful usually went straight to $E = V/d$ but did not know what to use for E, which was often confused with energy.

Question 3

In part (a)(i) most appreciated that an electron antineutrino had to be emitted. The correct terminology was not always known and ambiguous use of terminology expressing this as an 'anti electron neutrino', sometimes with hyphens before and/or after electron, was reluctantly given credit as there was only one mark available. In part (a)(ii) recall from AS content in this area was not as good as expected. A quarter of the students gave the correct response, most giving general laws of conservation of energy or momentum rather than the specific law relating to particle physics.

Part (b)(i) answers were often vague and ambiguous as to whether they were referring to biological or the physical half-life of the nuclide. In part (b)(ii) the method of using the data was known by the majority and most provided sufficient evidence to gain full marks. However, the structure of the responses was frequently less rigorous than hoped for at this level.

In part (c)(i) a high proportion of the students was able to arrive at the correct number of atoms or moles but there were a significant proportion who misread -5 for -6 in the index for the decay constant. Finding the mass form either of these proved problematic for many. A common problem was multiplying moles by 123 and, believing this to give the mass in kg, going on to multiply by 100 to give the mas in g. 2/3 students did part (c)(ii) correctly. Relatively few recognised 4 half-lives so used the formula. Using 240 for A and 15 for A_o was a frequently seen error.

Most students were able to make sensible comments in part (d)(i). In part (d)(ii) students were expected to provide more than simply stating that that iodine has a short half-life and emits only gamma radiation. Some explanation as to why this makes it the preferred option was required.

Most responses for part (e) concentrated on the effect of radiation on unwanted and healthy cells and many made no specific reference to the iodine context. A good proportion mentioned that iodine is specifically used by the thyroid. Some of these went on to explain that radioactive isotopes and non-radioactive isotopes are used in the same way by the body and the better students explained that this is because the radioactivity is a property of the nucleus whereas the use in the body is determined by atomic structure. Relatively few students, having mentioned the use as a tracer gave any further details. High quality answers were, consequently, relatively rare.

Question 4

Part (a)(i) was completed successfully by 2/3 of the students. In part (a)(ii) there were many disappointing attempts at this question which is a routine calculation in the context of nuclear fusion or interactions between two similarly charged particles. This has to be tackled from the point of view of change of KE to PE as particles approach but many tried to use the force equation. However, a good proportion arrived at double the correct answer using the kinetic energy of one particles, forgetting that each of the particles has an energy of 0.75 eV. In part (a)(iii) the points about electrostatic repulsion and/or the role of the strong force were appreciated by a large proportion of the students. Relatively few made an appropriate comment about what the closest distance of approach needed to be.

Part (b)(i) was usually well done but many students misread the index for pressure, using 10^6 rather than 10^{16}. Some used the correct power of 10 in the substitution and then misread their own figure in subsequent working. Allowing any errors carried forward part (b)(ii) was well done.

Part (c)(i) was a relatively straightforward 'show that' question which was well done by a majority of the students. Not showing sufficient working cost students a mark. There were a number of ways to approach part (c)(ii) and there was a good proportion of well set out responses. Most students appreciated that somewhere the mass-energy relationship needed to be used but a significant number of students substituted a mass for *E.* Some students produced relevant calculations but made no specific conclusion as to whether or how their figures demonstrated consistency or otherwise.

Question 5

Part (a)(i) was usually correct. For part (a)(ii) the majority stated that boron absorbs neutrons but to gain the second mark students needs to express explicitly the effect this had on the fission reactions taking place.

In part (b) there were correct answers but also many vague responses such as 'uranium' or 'nuclear material'.

In part (c) the terms moderator and coolant were commonly given. Only the better discussed the process by which the moderator slows down the neutrons. The usual response for the coolant was not to discuss the process of cooling, but to concentrate on the transfer energy to the heat exchanger etc. This was allowed as an acceptable response. Weak answers stated that 'the water' (which water?) turned into steam using energy from the reactor without any reference to the heat exchanger.

In part (d)(i) many answers in the allowed range were seen. 5% was too low given the evidence form the graph. For part (d)(ii) some only read the nucleon number for **X** but the vast majority made an appropriate suggestion. Part (d)(iii) was often well done. Clear working was essential here as using the total energy released and the mass of a uranium nucleus gave the correct numerical answer for the wrong reasons. Recognition of the emission of some neutrons was the key to part (d)(iv). Explanations about the way emitted neutrons affect the motion of the fission products were often vague. The weakest students made totally inappropriate suggestions such as energy lost as heat or energy used to increase the temperature of the two fission products.

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