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Physics A PHYA5/2C

(Specification 2450)

Unit 5/2C: Applied Physics

Report on the Examination

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GCE Physics, Specification A, PHYA5/2C, Section A, Nuclear and Thermal Physics

General Comments

The paper was generally well received by candidates and there were plenty of opportunities for students to show their knowledge. All the marking points were used and some candidates gained full marks. There was also no indication that candidates lacked time to complete the examination.

Question 1

The more able candidates successfully negotiated the majority of this question but the less able found many pit-falls.

In part (a) most obtained the first mark but then did not obtain the anti-neutrino.

For part (b) some candidates did not identify the position of P. Position Q was easier for students to identify.

A majority of candidates could balance the number of neutrons in part (c)(i) to obtain the correct answer x = 4. Those that guessed the answer almost always gave the answer x = 3.

Part (c)(ii) was very discriminating. Less able candidates did not know how to balance the energies and only scored marks on the conversion from u to MeV. Some did not go directly from u to MeV and gave many lines of calculation. If correctly performed, they still got the mark for the conversion, but they had many opportunities to show errors and so tended to be less successful and missed the mark.

Question 2

Part (a) was very straightforward for most candidates but less than half could tackle part (b) effectively. Problems were seen at every stage. Some had no idea what was happening at all; some used the wrong charge on the aluminium nucleus and used $27 \times 1.6 \times 10^{-19}$ C; and some even changed the equation given in the question to the Coulomb law of force equation by introducing a squared term for the separation.

Question 3

Part (a) gave a much greater spread of marks than expected. About one third of candidates did not attempt to place a unit on the y-scale and less able candidates also could not recall the correct shape of the graph. At the top end, candidates allowed the graph to fall too steeply as the nucleon number increased and/or they had the peak in the wrong position. Only the more able candidates knew the height of the peak.

In part (b) only the more able candidates could use the idea of 'binding energy' in a coherent manner. Less able candidates did not really make any significant points that were worthy of marks. On a marking point, although the question starts with 'use the graph…', it was possible to score full marks without reference to the graph, as we allowed a reference to high and low nucleon numbers as being equivalent to being either side of the peak.

Question 4

Most candidates performed well in part (a).

In part (b) the less able candidates tended to score only one mark because they could not form the energy balance equation when both changes of temperature and changes of state were taking place.

Part (c) caught a majority of candidates out. Even grade A students were tempted to roll out the usual answer, 'the temperature would be less because heat is lost to the surroundings'. This statement scored no marks.

Question 5

The graph in part (a) was done well by most, but the less able candidates were not careful in reading the temperature scale and did not place the x-axis intercept at absolute zero. In some cases they had drawn a curve that had no intercept on the x-axis.

Parts (c) (d) and (e) were tacked well by more able candidates. The less able could only manage to do part (b) but then started either to substitute the wrong data, eg temperature in °C, or quote incorrect equations in the parts that followed. It was appreciated that not enough space was given to answer.

Part (e) allowed almost all candidates to score some marks, but the scores tended to be grouped in the following way. Less able candidates scored a couple of marks by discussing movement of molecules but did not go any further because of their poor use of physics in using phrases such as, 'the molecules have more energy and so hit each other harder giving more pressure'.

Some candidates started to use Newton's second law more effectively and referred to pressure in a more scientific manner.

The more able candidates could explain how increasing the volume allowed the pressure to remain constant as the temperature increased in terms of molecular motion.

GCE Physics, Specification A, PHYA5/2C, Section B, Applied Physics

General Comments

The vast majority of candidates were able to attempt all the questions and they appeared to have allowed themselves enough time on this section to answer the paper in full. The examiners saw many confident and high-scoring answers from candidates who were well prepared for the examination.

As is usually the case, candidates generally showed greater confidence with calculations than with written explanations or descriptions, although it was pleasing to see some very thorough and well written answers to question 2 (a), where marks were awarded for quality of written communication. In the 2010 examination, candidates were not prepared for question 3 on a refrigerator, but greater confidence was shown on this year's question 4 on a heat pump, indicating that centres have probably given the topic more attention. However, question 4 (b) did show that there is still some confusion with the symbols used in the equations.

Units were given on the answer lines to all calculations apart from question 2 (b)(iii) where candidates were instructed to give an appropriate unit for torque. It is surprising that many candidates were not able to give the unit, especially considering that the same unit was tested the previous year.

AQA are sorry that an erratum notice had to be given concerning two minor errors on the paper, one a spelling error and one a missing word ('the' in question 3). Candidates' work did not appear to be affected in any way by these errors.

It is recommended that all teachers of this option use the support booklet on Applied Physics. It can be downloaded here.

Question 1

In part (a), candidates were asked to state the law of conservation of angular momentum. Most were able to state that total angular momentum remains constant but less than one fifth of candidates scored the mark because they did not include the proviso that no external torque must act. Many stated that no external *force* must act, but this gained no credit.

Part (b)(i) was reasonably well answered, but to gain the second mark candidates had to relate their answer to the period of rotation of the star, and many went no further than to say the angular velocity would increase. There was a wide range of approaches to the calculation in (b)(ii), and it was pleasing to see answers where candidates spotted that because the mass m and the factors 0.4 and 2π cancelled, all that was required to find T_2 was to substitute in $R_1^2/T_1 = R_2^2/T_2$. The data in the question was given to two significant figures and a mark was awarded for giving the final answer to two significant figures. Too many lost this mark. An answer to three significant figures was all too common.

Question 2

In part (a) candidates were asked to write an extended descriptive answer on the design features of a flywheel used in a kinetic energy recovery system in order for it to store maximum energy, and they were told that the quality of their written answers would be assessed. Good answers started with $E_K = ½I\omega^2$ and $I = \Sigma mr^2$ and went on to discuss the importance of high speed, and how the moment of inertia is linked to the way the mass is distributed about the axis. Some candidates enhanced their answers with explanatory sketches.

The best answers also referred to how friction could be reduced, the need for high tensile strength to cope with centripetal forces, and the use of high density materials, or high density at the rim but low density closer to the axis. Some candidates even specified suitable materials. Marks were lost by candidates who concentrated only on shape and mass and failed to discuss either the materials or 'design for high angular speeds'. A surprising number of candidates incorrectly emphasised that I should be as small as possible, since they believed this would automatically enable the flywheel to reach high angular speeds. Some referred to the context in which the question was set – and realised that there was a trade-off between high mass for high moment of inertia and the need for keeping the car's mass down. Some candidates hardly mentioned energy at all and concentrated on torque, which gained very little credit.

In part (b)(i) only about half of the candidates scored the mark. Common errors were using only one of the given speeds in $E_K = ½I\omega^2$, or thinking that $E_K = ½I(\omega_1 – \omega_2)^2$ is the same mathematically as $E_K = ½I(\omega_1^2 – \omega_2^2)$. A generous 'carried error' enabled them to score on subsequent parts of the question.

Parts (b)(ii) and (iii) were generally answered well, but many lost the unit mark in (b)(iii). As in the previous paper, units given in SI base units (kg m^2 $s^{–2}$) were not accepted as "appropriate".

In (b)(iv), $\theta = ½(\omega_1 + \omega_2)t$ was usually applied correctly to find the angular displacement in radians. An alternative was to use the angular deceleration and substitute in $\theta = \omega_1 t +½ \alpha t^2$, though some did not to appreciate that a deceleration needs a minus sign.

Question 3

This question concerned the cycle of a 'hot air' engine (actually the Stirling Cycle). The specification states that 'where questions are set on other cycles (ie other than petrol or Diesel), they will be interpretive and all essential information will be given'; therefore, the scene was set carefully.

Part (a)(i) asked candidates to 'show that' the temperature at D (the maximum temperature) was 500 K. Those candidates who substituted pressures volumes and temperatures into $P_AV_A/T_A = P_DV_D/T_D$ correctly and on the next line wrote 'T_D = 500 K' could score one out of the two marks. Because they had to 'show that', the answer is 500 K, the examiners looked for some extra manipulation, such as rearranging the equation, in order to award the second mark. It is very important that candidates do make some effort in this type of question to **write down all the steps**, even though they might be able to arrive at the correct answer simply by doing some of the working in their heads, or by carrying numbers through a calculation on the calculator.

In part (a)(ii) The application of the first law of thermodynamics to an isothermal process was well understood by many, but a small proportion of candidates confused Q and ΔU.

All candidates had to do in part (b)(i) was subtract the compression work from the expansion work, most were able to do this.

In part (b)(ii) the majority of the candidates scored the mark for calculating the maximum theoretical efficiency using the 'hot' and 'cold' temperatures. It was surprising that a number of candidates who had not been able to do part (a)(ii) were able to correctly calculate the cycle efficiency using net output work divided by energy input by heat transfer.

The majority of candidates were able to sketch the cycle on $V – T$ axes asked for in part (c). Those who did not score full marks either missed the labels off, or put the labels in the wrong place. Some placed the labels in the correct positions, but did not draw a rectangle.

Answers to part (d) were on the whole disappointing. Candidates were told that in the engine a fixed mass of air is continuously taken through a cycle of compression, heating, expansion and cooling. All too often answers were written in terms of a petrol or diesel engine, referring to valve operation, incomplete combustion, or rounded corners of the indicator diagram. Others simply wrote that there would be friction, or that it would not be 100% efficient because it would lose heat to the surroundings (they had just shown in (b)(ii) that the engine was 40% efficient and as efficient as it could possibly be for the given temperatures).

Candidates who simply stated that isothermal and constant volume processes are impossible, or it is impossible to build a 100% efficient regenerator, without giving any further reasoning were not given credit. Marks were given to answers that showed the candidate had thought about the problems posed by such a cycle – for example, the engine would have to be slow for nearly isothermal processes, for constant volume processes to occur it would have to stop twice per cycle, or the regenerator would lose some heat to the surroundings unless it was perfectly insulated.

Question 4

The most common error in part (a)(i) was to divide the 780 W input by the coefficient of performance instead of multiplying. The easier route to the answer for (b)(ii) was to use $Q_{out} = Q_{in} - W$, but many used the more laborious $COP_{HP} = Q_{in}/(Q_{in} - Q_{out})$.

In part (b) candidates were asked to comment on the statement 'a heat pump supplies more energy than is supplied to it' in the light of the law of conservation of energy and the second law of thermodynamics. Many quoted the formulae from the *Data and Formulae Booklet*, but it was clear from the answers to both parts (a) and (b) that many candidates had no real understanding of the meaning of Q_{out}, Q_{in} and W applied to a reversed heat engine, or the relationship between them.

There were vague answers that referred to 'the surroundings' without stating whether they meant the cold space (ground) or the heated space (workshop). Similarly, many wrote about the 'energy input' without making it clear which energy input they meant (eg from the cold space or the electrical energy supplied or the energy input into the hot space).

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