OXFORD
INTERNATIONAL
AQA EXAMINATIONS

INTERNATIONAL A-LEVEL PHYSICS

(9630) PH04 – Energy and energy resources
Report on the examination

June 2022

REPORT ON EXAMINATION: INTERNATIONAL A-LEVEL PHYSICS (9630) PH04 – ENERGY AND ENERGY RESOURCES – JUNE 2022

This paper was of a similar demand to previous ones. There was good performance in each of the three topics assessed in this unit. In Section A, marks were more often gained through calculations than by written answers. Those found to be particularly challenging were **01.3**, **02.1**, **03.4** and **06.8**.

Students were generally successful throughout Section B.

SECTION A

QUESTION 01

01.1 About three-quarters of the cohort gave a temperature in the correct range.

01.2 Nearly 50% of students gained full marks in this question. The first mark was considered a practical skill for using a correct duration of the freezing process. Some students failed to read the time unit on the graph and did not convert from minutes to seconds.

01.3 About one-quarter of the cohort described what happened to the average kinetic energy and the average potential energy during the specified time period. Students who gained only one mark often described the whole time period correctly but only for one energy.

QUESTION 02

02.1 Most students gained one or two marks in this question. The most common response addressed the first marking point and described a decrease in the speed of the particles. Some students went on to state the consequence of this decrease in terms of the frequency of collisions or the momentum change. Access to the third and fourth marking points required students to give a clear description connecting a decreased rate of momentum change to the force. Very few students referred to the <u>mean</u> speed of the particles decreasing, which was condoned in this series.

02.2 This question discriminated well. In algebraic answers to '*show that*' questions, students are expected to state the initial equations clearly and to show a complete chain of argument leading to the required result. In this question, both the equations for density and for molar mass were required, together with their substitution into the ideal gas equation.

02.3 Students generally coped with this question very well, with 40% gaining full credit. A common error in obtaining the gradient was the use of $240\ °C$, instead of $260\ °C$, as the change in temperature.

QUESTION 03

03.1 Over 80% of students gained the mark here by showing sufficient working leading to a value of at least three significant figures.

03.2 There was similar success for students with this numerical '*show that*' question. Students who gained only one mark usually did not state the initial algebraic equation for rotational kinetic energy, or they gave the final answer in MJ rather than in J.

03.3 A majority of the cohort correctly determined the final angular speed by one of the two methods. There was no obvious preference for either. Many students obtained the angular acceleration or the change in angular speed but then ended up with an increase in angular speed. Some students failed to realise that the angular speed of the flywheel was not constant and tried to determine an angular displacement.

03.4 This question proved challenging for most students, with about half the cohort failing to score any marks. Many aspects of the information provided in the question were not appreciated. Two points in particular were: the flywheels had the same dimensions; and they were to store the same amount of rotational kinetic energy. The most common response linked density and moment of inertia. Some students went on to describe how a change in the moment of inertia would affect the angular speed when the rotational kinetic energy was the same. Comments about the breaking stress lacked sufficient technical precision, often omitting any reference to the centripetal force. When this was mentioned, it was frequently linked to a situation in which the flywheel changed angular speed. The context of the question was for a constant rotational kinetic energy, and so constant angular speed.

QUESTION 04

04.1 This question discriminated well with students having the opportunity to find a solution by several methods. Whichever method was chosen, the contributions of the proton's rest-mass and kinetic energy needed to be included. Forgetting to include the rest-mass was more common.

04.2 Many students stated that both momenta would be the same (in magnitude) but failed to state that they were opposite in direction. Those students who appreciated this often showed that the speed of the alpha particle would be double that of the beryllium nucleus, according to the mass ratio. Some students found the consequences of the mass differences and speeds too challenging for them to be able to deduce the correct relationship between the kinetic energies.

04.3 About 40% of students gained full credit in this question. Common errors were: not quoting an initial equation; including an r^2 term; or giving the final answer in fm rather than m.

04.4 Most students gave some response to this question. The most common correct statements were that the closest-approach method depends on the kinetic energy of the alpha particle, or that it gives an over-estimate. A statement seen frequently by examiners was that the closest-approach method relies on a calculation but electron diffraction gives a direct measurement.

QUESTION 05

05.1 Nearly 60% of students gained full credit. Not converting the distance from km to m was the most common reason for only getting one mark.

05.2 About three-quarters of the cohort gained both marks.

05.3 Students did very well at this question, with nearly 80% gaining all three marks.

05.4 Nearly 55% of students obtained full credit here. Most students obtained an initial rate of energy transfer of $410\ \mathrm{kW}$ and stated that, as this was greater than $100\ \mathrm{kW}$, the floor was unsuitable. Some students made a comparison of the thickness of the floor. Comparisons with temperature difference, thermal conductivity, or area were also possible and permitted. Common errors made by those students not gaining full credit were: not converting the diameter to a radius; using an incorrect temperature difference; or not making an explicit comparison of their deduced value to the relevant one given in the stem.

QUESTION 06

06.1 Nearly two-thirds of the cohort gave a correct definition. Many fell short by referring simply to constituent "particles", rather than nucleons or protons and neutrons. It was worrying to see references to "atoms", or even "molecules" in this definition at this level.

06.2 About 60% of the cohort handled this nuclear-energy calculation well to gain all four marks. Students were expected to use the accurate values for the proton and neutron masses, rather than the approximation of 1.67×10^{-27} kg. Inclusion of the mass of the electrons was not condoned.

06.3 Students who did not get this mark made one of two mistakes: putting 233 for the proton number and 91 for the nucleon number; or putting 91 for the proton number and 142 for the nucleon number.

06.4 As with **06.2**, most students were competent with this nuclear-energy equation. The most frequent error was to include the neutron(s) in their calculation.

06.5 Few students gave a relevant answer to this question. Many responses were along the correct lines in stating that the number of emitted neutrons would be different, but did not specify the reason (that this leads to different pairs of nuclides). Many appeared to misunderstand the question – which required the average energy released per fission – by suggesting that not all the uranium–233 nuclei would undergo induced fission.

06.6 For full credit, students had to quote and use the equations for density and for the volume of a sphere. An answer with those equations directly combined gained no marks. For such questions, students should imagine they are presenting the answer to a student working at a stage below their own level of learning.

06.7 Nearly 75% of students achieved full credit here. The common mistakes were using the area of a circle (rather than a sphere), or not converting from cm to m.

06.8 Students found this question very challenging. About 15% gained one mark, usually for stating that a larger surface area would lead to a greater loss of neutrons. Few students went on to explain that this would reduce the rate of induced fission below the condition needed for a sustained chain reaction. One frequently seen misconception was that the number of neutrons produced would decrease. The mass of uranium–233 in the cylinder was the same (at 16 kg) so the rate of neutron production would not change.

SECTION B

Students did not find any of these questions too challenging.

Questions 9, 10, 15, 19, 20 and 21 were particularly well done.

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