INTERNATIONAL A-LEVEL PHYSICS

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

January 2022

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

This paper was of similar demand to those of previous series. The cohort performed well across the three main specification areas, Thermal Physics, Nuclear Energy and Energy Sources.

As in previous series, students tended to perform better in the calculation questions with a wider spread of results in the long- and short-answer worded questions. One particular area of weakness for this cohort was the appropriate use of exact scientific terminology. Many students gave descriptions that were far more vague than is allowed at Advanced level. For example, "*as temperature increases, volume increases*" is not an acceptable alternative for "*volume is directly proportional to temperature*".

This cohort performed comparatively slightly less well in Section B, the multiple-choice section; in previous series many students scored better in section B than A.

Students should be reminded of some conventions applied by examiners in all papers in this specification:

- in 'show that' questions, the final mark is awarded for giving the answer to at least one more significant figure than that stated in the question;
- when determining a gradient, the points used to determine the gradient of a line must range over at least half the length of the line;
- numerical answers rounded to one significant figure are normally penalised unless there is an appropriate reason (for example, an answer that is an integer value in the range 1 to 9);
- students must write in English sentences rather than writing algebraic shorthand, e.g. 'W>0'. When algebraic shorthand is used, all terms must be defined and related to the context.

QUESTION 01

Questions 01.1 and 01.2 were very well answered, with a majority of students scoring full marks in each. Some students lost a mark in 01.1 by quoting too few significant figures in their answer. Question 01.3 was less well answered. One mistake made by some students was the failure to relate their explanation to the context. Others answered purely in algebraic shorthand, e.g. "$Q = 0$". This cannot gain credit unless terms have been defined and linked to the context. A separate misconception was that heat is lost from the gas to the surroundings; this is not the case when the inflation is rapid.

QUESTION 02

This question about rotational dynamics was well answered by the majority. In 02.1 particularly, most scored full marks. In 02.2, some forgot to divide the mass by three. In 02.3 a high majority scored three out of the four marks although many lost the final mark by failing to combine correctly the resultant and frictional torques.

QUESTION 03

This question was less well answered on the whole and it was clear that many students did not understand the purpose of a pumped-storage system.

03.1 was generally well answered but the delta (Δ) signs were required. Some students completed the derivation without any delta signs but added them at the end. This is neither rigorous nor creditworthy. 03.2, a straightforward calculation, was well answered by almost every student.

In 03.3, a high-level response with specific detail was required. For example "*friction in the turbine*" is not sufficient for this mark at Advanced level, but "*friction in the bearings of the turbine*" was credited. Only a small proportion of students scored full marks for this question (around 10%). 03.4 was also poorly answered. While many students understood the need to find the area of the graph, many did not combine the two areas correctly (above and below the axis) or failed to determine the value of energy that corresponds to one of their squares.

03.5 was very poorly answered. Many students did not demonstrate any understanding that the energy generated in the generating stage is re-invested during the pumping stage. More energy is required to pump the water back to the reservoir than is generated. 03.6 was slightly better answered, although some students lost marks by stating that power (rather than energy) is stored.

QUESTION 04

Both calculations were well answered. In 04.1, the vast majority were able to calculate at least one of the intensities correctly, although some divided the ratio the wrong way around. 04.2 was answered well, with over 80% of the cohort scoring full marks.

QUESTION 05

Question 05.1 required a rigorous quantified explanation. The answers of many students were too vague for credit. For example, "*length is proportional to volume as cross-sectional area is constant*" is a more exact answer than "*volume increases so the length increases*". In 05.2, most students recognised the need to extrapolate but some extrapolated artificially to –273 °C, which is not a satisfactory practical procedure. Additionally, as the extrapolation method is so imprecise, answers to more than three significant figures were penalised.

05.3 was quite well answered although some students incorrectly chose absolute zero as their data point. This would not yield any information about the size of the tube. 05.4 was very poorly answered. Very few students recognised that the main source of uncertainty in this method is that extrapolation is an imprecise method. Others mistakenly suggested that the temperature of the gas is being reduced to absolute zero and they commented on how unfeasible this is, showing a misunderstanding of Required Practical Activity 9. Question 05.5 was generally well answered as it demands a similar skill to 05.2.

QUESTION 06

06.1 was not well answered even though it is an AO1 question (testing knowledge without a novel context). 06.2 was better answered but many students tried to derive the relationship for one nucleon rather than for a general nucleus (e.g. using $m = u$ rather than $m = Au$). 06.3 was answered better, however a gradient calculation had to be clearly shown. Again, two significant figures were required for the final mark.

QUESTION 07

07.1 required a straightforward definition and was very poorly answered. As in previous series, students do not seem well prepared for such questions. 07.2 and 07.3 were both relatively well answered. In 07.2, a few students incorrectly combined the binding energy per nucleon instead of multiplying by nucleon number first.

07.4 was not so well answered. Although a majority scored one mark out of the three available, a relatively high proportion left the question completely blank. This may perhaps be because it concerned thermal physics within the context of a nuclear-energy question. Although synoptic questions are mostly found in PH05, some cross-topic questions can be expected, particularly in PH03 and PH04.

07.5 was also very poorly answered with the majority only scoring one of the three marks. This is a question that might reasonably be found in a GCSE examination. Many students scored the first marking point. However, to score MP2 and MP3 a rigorous and exact explanation was required with a description of how a constant rate of fission is obtained and its relevance to a constant power output.

SECTION B

The multiple-choice section was less well answered than in some previous series, with the average score in this section only a little over half marks.

Students performed well (around 70% or more correct) on questions 13, 19 and 21.

Students performed poorly (around 40% or fewer correct) on the following questions:

- **12:** more students actually chose C rather than the correct answer B. These are the graphs for an isothermal and an isovolumetric change respectively, rather than an isobaric change.
- **14:** the same number of students chose B as chose the correct answer A. They were not aware of whether a moderator should be a good neutron absorber or not.
- **15:** more students chose D than the correct answer B. Nuclei have to be significantly larger than a nucleon number A of 100 before releasing energy in fission (in reality usually $A > 200$ or so).
- **16**: students chose each option almost equally here. For the correct answer, the energies must be added twice for the first two processes, once for the third, then divided by four for the four input protons.

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