AQA
Questions matter

AS
Physics

7407/1 Paper 1

Report on the Examination

7407
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General Comments

This paper was very similar to those of previous series. The mark scheme was also constructed in a similar way, crediting students who provide partial working towards the correct answer. The questions gave students opportunities to demonstrate their knowledge and understanding across many parts of the specification. There was a variety of question styles with varying levels of difficulty. The paper produced a good spread of marks and students in general were able to produce work that reflected their level of understanding.

Question 1

01.1

The wording in the question indicated that more than one conservation law was involved in this explanation. Most students achieved at least one mark for stating that the emitted particle had to be an electron to conserve lepton number or to conserve charge. They often provided an analysis of the lepton numbers or charges of the particles but did not always appreciate that both the lepton number and charge had to be conserved, to explain why it was an electron that was emitted.

Many students demonstrated a good understanding of the interaction and wrote equations in terms of neutron, proton and electron rather than the whole nuclei. Some students gained the second mark by providing a quantitative analysis of the interaction in terms of charge, lepton number (and baryon number) without making a statement about their conservation.

01.2

Almost half of the students gained two marks for this calculation.
Approximately 80% of the students achieved at least one mark for making some progress towards the correct answer. Students gaining one mark were able to find the mass or the charge of the argon-37 nucleus. However, a considerable number choose to use a charge of $17e$ (chlorine-37) rather than $18e$ (argon-37) when finding the specific charge. Another common error was the inclusion of the mass and charge of what would have been atomic electrons.

01.3

This part of the question posed a greater challenge with less than 20% of students gaining four marks. However, nearly 80% were able to score at least one mark. Typically, students scored one mark for:

- identifying W^+ as the exchange particle without being able to provide any reason why
- recognising this interaction as electron capture or
- stating that this was the weak nuclear interaction.

Many students thought that a neutron changed into a proton in this interaction and found it difficult to access more than two marks. Others commented on the effect the interaction had on the baryon number rather than on the baryon.
Typically, higher attaining students presented work that was easy to follow and clearly linked their reason to the appropriate deduction.

01.4

The students performed well in this levels of response question.
Over 20% of students gained at least five marks. These students' answers were well-structured and contained good detail on the electromagnetic force and the strong interaction.
Over 60% of students gained at least three marks. These students were able to provide a detailed description of the role of the strong interaction including ranges for attraction and repulsion. However, they were less sure of the electromagnetic force and its exchange particle. Others discussed the decay modes of an unstable nucleus and the role of the weak interaction in these decays.
Lower attaining students could typically state that the protons repel each other, and that the strong interaction opposes this but were unable to give any more detail.

Question 2

02.1

Over 40% of students gained this mark.
Many students converted $6.7\ \mathrm{eV}$ into $1.1 \times 10^{-18}\ \mathrm{J}$ and gave this as their answer. Others then used $W=QV$ with W equal to 1.1×10^{-18} (J) to determine the potential difference V. Very few had a direct approach of recognising that $6.7\ \mathrm{eV}$ of work on the electron requires a potential difference of $6.7\ \mathrm{V}$. Many students divided 6.7 (eV) by the charge on an electron and presented 4.2×10^{19} as their answer.

02.2

Over 60 % of students gained all three marks. The work from these students was well presented showing each of the cognitive steps involved in arriving at the answer. Approximately equal numbers of students used the equation $E = \dfrac{hc}{\lambda}$ or the equations $E = hf$ and $c = f\lambda$ to answer the question.
Lower attaining students often:

- used $6.7\ \mathrm{eV}$ as their energy rather than converting this quantity to joules,
- attempted the conversion but did this incorrectly, and
- incorrectly rounded their final answer.

All these errors were considered in the mark scheme and students could obtain compensatory marks for partial working towards the correct answer.

02.3

This is another question that worked well in discriminating between students. Over 10% of students gained three marks or more whereas approximately 50% gained at least two marks.
Typically, students scoring two marks only answered the absorption aspect of the question. They described how the atomic electron accepted the $18.4\ \mathrm{eV}$ and moved from ground state to level **B** and then stopped, thinking that they had completely answered the question. Some attempted to describe the emission of the visible photon but chose the wrong transition suggesting that the electron moved directly from **B** to the ground state and that the $18.4\ \mathrm{eV}$ photon was visible.
The most able students identified the transition from **B** to **A** as being responsible for the emission of a visible photon. They calculated the wavelength of this light and knew that this wavelength lay inside the visible range.

Very few referred to the information given in the stem above **02.2**; the 6.7 eV photon was identified as a photon of ultraviolet radiation. They could have made a comparison of the photon energies of the transitions **B** to **A**, **A** to ground state, and **B** to ground state with 6.7 eV to decide which transition was responsible for the photon of visible light.

Question 3

03.1

Approximately 50% of students gained two marks with almost 90% able to gain at least one mark.
Many students failed to recognise that this was a stationary wave in its first harmonic. They used the length of the string as the wavelength and substituted this into the wave equation, obtaining an answer of $95\ \text{m s}^{-1}$. Others recognised that the wavelength was not the length of the string but halved the length rather than doubling it.
Two errors seen in working meant that the first marking point was not awarded. For example, students using the length as the wavelength and forgetting to convert 648 mm to 0.648 m did not score this compensatory mark.

03.2

Again, the question worked well in discriminating between students with almost 70 % gaining at least one mark for determining the mass per unit length while almost 35% gained all three marks by correctly determining the mass of the string between **X** and **Y**. However, it concerned examiners that, in many cases where students determined the mass per unit length μ, this was presented as their final answer. They seemed unaware that the mass between **X** and **Y** and μ were not the same thing. Of those who did recognise that another cognitive step was required, some divided μ by their length instead of multiplying. Students who gained two marks typically made one error in using the equation $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ but went on correctly to use their μ to determine the mass between **X** and **Y**.
Lower attaining students treated T as the period rather than the tension or attempted to use a range of incorrect equations that included mass as one of the terms.

03.3

Nearly 20% of students gained all three marks. Their stationary wave had been drawn correctly with the appropriate attention to detail ensuring:

- the envelopes were similar in width and height
- all nodes and antinodes were correctly indicated.

Students who drew uneven loops did not obtain the third marking point. Other students lost the third mark for labelling the antinode at two positions on one loop. They confused the antinode, the position where maximum displacement occurs, with the position of minimum displacement.
Lower attaining students drew the incorrect number of envelopes, they did not understand how f_3 was related to the fundamental f_1. Some, having drawn some envelopes, were unable to identify correctly the position of any nodes or antinodes.

03.4

Students found this question challenging with fewer than 50% gaining any marks. Those who made limited progress often recognised that point **Z** had become a node but were less sure on how this affected the modes of vibration and the relative amplitudes on the string shown in **Figure 4**.
Others were able to identify that f_2 was present but were unable to describe why this was the case.

Question 4

04.1

Many good responses were seen here with over 80% of the students gaining both marks.
Where students lost a mark, typically they:

- found the time $t = 8.9$ s and made no further progress
- after finding the time, used $s = vt$ instead of $s = \frac{u+v}{2}\, t$ leading to double the answer for s as they had not found the average velocity
- rounded their final answer incorrectly.

04.2

This was an accessible calculation with over 70% of students gaining two marks. Where students lost a mark, typically they:

- used the weight of 2500 N for mass m
- incorrectly rounded *m* affecting the accuracy of their final answer
- added 2500 N to P_H

04.3

Over 50% of students gained all three marks in this question. Most of these students used Pythagoras's theorem rather than trigonometric ratios. Students gaining one mark usually subtracted the forces disregarding their vector nature and used their value of $P_H = 150$ N to successfully read-off a value for v_1 from **Figure 9**. However, some were unable to perform this read-off with an appropriate level of accuracy and obtained zero marks.

04.4

Many students had difficulty accessing this mark due to inaccurate or vague technical language. They were unable to use phrases such as '*line of action*' or '*perpendicular distance*' and consequently had difficulty expressing their understanding of the situation in a way that was deemed acceptable.
Some thought that only vertical forces could have a moment which discounted forces that had a vertical and a horizontal component. They also seemed to be unaware that P_H would have a moment when its line of action did not pass through the centre of the wheel.

04.5

Only the higher attaining students were able to make much progress here. Almost 20% of students gained three marks whereas almost 70% scored zero. Just over 30% of students didn't even make any

attempt at this question. Those who applied the principle of moments generally went on to gain all three marks.
One of the purposes of question **04.4** was to introduce moments to the students and act as a stimulus for **04.5**. That hint proved too subtle for all but the best students.

04.6

Students generally find descriptive answers more challenging than quantitative answers. This question demonstrated students' inability to construct answers that link the appropriate physics to the context. Lower attaining students were able to state Newton's laws of motion but were unable to apply any of them to this context. They typically limited themselves to re-stating information given in the question without being able to develop their answer. They sometimes gained the first marking point for realising that the trailer collides more frequently with the particles in the air as the speed increased.

Nearly 20% of students gained two marks and these were usually gained for marking points one and three. Accessing the Newton's second law mark proved too challenging for all but the most able.

04.7

Almost 50% of the students managed this calculation correctly and obtained three marks.

Many students were able to gain one mark for use of $P=Fv$. They calculated the driving force of the car as 3800 N or the rate of work done by the resistive forces acting on the trailer but did not know how to proceed. Those who gained two marks typically determined the resistive force on the car as 3100 N but gave this as their final answer. Others obtained the correct answer of 700 N but then went on to subtract or add it to 3800 N.

Question 5

05.1

Almost 50% of students scored this mark.
A variety of curved graphs were seen with students considering the filament lamp without thinking about how it operates for current in the range 0 to 0.5 A. Students need to pay more attention to the stimulus material such as that provided in **Figure 13**.
There were many straight lines through the origin seen but unfortunately most lacked accuracy at the (0.50 A, 0.375 V) coordinate to access the mark.
Students need to ensure that they produce diagrammatic work that has an appropriate level of accuracy.

05.2

Over 50% of students obtained two marks in this calculation while over 80% gained at least one mark.
Students failed to gain marks due to:

- misreading from **Figure 13**, obtaining a resistance of 3.8 Ω rather than 3.6 Ω, giving a final answer of 13.7 W.
- using $P=VI$ with incorrect values for V such as 9.0 V or 0.375 V.

05.3

Well over 90% of students gained at least one mark with over 25% gaining both marks.
Most students who gained one mark obtained the resistance of the lamp as $2.2\ \Omega$ and presented this as their final answer. They determined the resistance by either using $V=IR$ or reading-off the resistance from **Figure 13**. Of those who realised that more was required, they mostly chose to determine the total resistance in the circuit and subtract the lamp's resistance to find R's resistance. Some lost the second mark through arithmetic errors such as $9 - 3.3 = 6.7$ instead of 5.7.

05.4

Nearly 40% of students scored zero marks in this question.
Those who made some progress had difficulty in connecting their ideas together to construct a well-structured coherent answer. There was much confusion about how the current was affected by the addition of the extra lamp; a common misunderstanding was that although the current split between the lamps the total current remained the same. Others thought that adding another lamp in parallel would increase the resistance of the circuit.
A significant number assumed that the total resistance in the circuit had to remain constant. They reasoned that R's value had to increase to balance the decrease in the resistance of the lamps.
Only higher attaining students recognised the voltage aspect of the question and could construct answers that described how R's resistance had to decrease to maintain the same voltage across it when the second lamp is added to the circuit.

Question 6

06.1

Just over 30% of students selected the correct answer. It was a challenging introduction to the question. However, options 3 and 4 could have been discounted quite quickly as the boy begins in free-fall at a constant acceleration where an increase in velocity would be seen. The fact that the boy's velocity had started to decrease after 15 m would indicate that his acceleration had changed well before this distance. Checking to see if the change in gravitational potential energy equalled the change in kinetic energy would show that this was true at $s = 7.5\text{ m}$ but not true at $s = 15\text{m}$, meaning that free-fall ended between 7.5 m and 15 m.

06.2

This was a very accessible question with over 80% of students gaining both marks.

06.3

Nearly 10% of students obtained all three marks.
This question proved challenging, with many students struggling to understand what was happening in the question. These students typically used 7.71 kJ for the energy stored in the rope. The question required them to realise there were three kinds of energy to consider: E_p, E_k and elastic potential energy. Almost all who realised that elastic potential energy could be found by subtracting E_k from the initial E_p went on to obtain all three marks.

06.4

Approximately 20% of students did not attempt this question. Students were not sure where the maximum kinetic energy occurred and often attempted gravitational potential energy to kinetic energy explanations without considering the role of elastic potential energy in this situation. Many could determine the tension but were not able to give a valid reason for this.
There were two valid routes to obtain both marks and successful students were seen choosing either. The route using $F = k\,\Delta L$ was generally more successful at gaining both marks.

06.5

This question was very accessible with almost 70% of students gaining the mark. It is important for students to include sufficient working to support this type of ‘show that’ question.

06.6

Many students were able to identify that the boy’s maximum speed increased when using the second rope due to it having a greater unstretched length and that he would spend longer in free-fall and therefore be travelling faster when the rope begins to stretch. However, it was much less usual to see answers that moved beyond this, realising that the kinetic energy continued to increase as the rope began to stretch.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.