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Examiners' Report
June 2022

IAL Physics WPH14 01

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Introduction

The assessment structure of Unit 4: Further Mechanics, Fields and Particles is the same as that of Units 1, 2 and 5, consisting of Section A with ten multiple choice questions and Section B with a number of short answer questions followed by some longer, structured questions based on contexts of varying familiarity.

This paper allowed candidates of all abilities to demonstrate their knowledge and understanding of Physics by applying them to a range of contexts with differing levels of familiarity.

Candidates at the lower end of the range could complete calculations involving simple substitution and limited rearrangement, including short structured series of calculations, but could not always tackle calculations involving several steps or other complications, such as calculating range when there is a difference in height between the launch point and the landing point. They also knew some significant points in explanations linked to standard situations, such as electromagnetic induction, alpha scattering and linear accelerators, but missed important details and did not always set out their ideas in a logical sequence, sometimes just quoting as many key points as they could remember from the mark schemes of previous papers without particular reference to the specific context.

Steady improvement was demonstrated in all of these areas through the range of increasing ability and at the higher end all calculations were completed faultlessly, with most points included in ordered explanations of the situations in the questions.

Section A

The multiple choice questions discriminated well, with performance improving across the ability range for all items.

The percentages with correct responses for the whole cohort are shown in the table.

Question	Percentage of correct responses
1	77
2	64
3	42
4	67
5	39
6	63
7	50
8	75
9	83
10	25

More details on the rationale behind the incorrect answers for each multiple choice question can be found in the published mark scheme.

Question 11

Most candidates were awarded at least the first mark for the use of $W = mg$, although some used the mass of water flowing per second or added both masses. Nearly half of the candidates went on to gain full marks by the application of Newton's second law in the force equals rate of change of momentum form.

A significant number of candidates were unsure of how to deal with a mass flow rate and attempted some method of equating kinetic energy with gravitational potential energy gained per second. Others attempted to calculate a relevant time and use equations of motion.

Candidates occasionally omitted the unit for their answer and so were not awarded the final mark as quantities required a magnitude and a unit.

Calculate the velocity of the jet of water as it leaves the flyboard. Assume the water has negligible velocity before it leaves the flyboard.

mass of person and flyboard equipment = 175 kg
mass flow rate of water = $114\,\text{kg s}^{-1}$

$F = \frac{mv - mu}{t}$ $\quad$ $w = mg$

$1716.75\,\text{N} = \frac{mv - mu}{t}$

$1716.75 = \frac{114 \times v - 114 \times 0}{1}$

$v = 15\,\text{m s}^{-1}$

Velocity of water jet = $15\,\text{m s}^{-1}$

(Total for Question 11 = 3 marks)

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Examiner Comments

3 marks.

This candidate has set out their solution very clearly in terms of Newton's second law, arriving at the correct answer straightforwardly.

Calculate the velocity of the jet of water as it leaves the flyboard. Assume the water has negligible velocity before it leaves the flyboard.

mass of person and flyboard equipment = 175 kg
mass flow rate of water = 114 kg s^{-1}

kg m s^{-2} ÷ kg s^{-1}
= m s^{-1}

mg = force by wle

175 × 9.81 = 1716.75 N

$V = \frac{1716.75}{114} = 15.06 \text{ m s}^{-1}$

Velocity of water jet = 15.06 m s^{-1}

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Examiner Comments

3 marks.

The majority of candidates started with a weight calculation, but many did not know what to do next. The number of possibilities is limited, but this candidate has carefully carried out a dimensional analysis of the units to confirm that dividing by the mass flow rate is valid.

Question 12 (a)

The majority of candidates were able to state this satisfactorily. Those who did not usually gave insufficient detail, stating that energy is conserved, for example, without mention of kinetic. Conservation of momentum was often mentioned as well.

State what is meant by inelastic.

(1)

Energy is transfered away from the balls, thus the total energy is not conserved in the collision.

ResultsPlus Examiner Comments

0 marks.

This does not include sufficient specific detail because it does not include 'kinetic'. The total energy is always conserved.

State what is meant by inelastic.

(1)

There was no energy conservation during the collision

$KE_1 \neq KE_2$

ResultsPlus Examiner Comments

0 marks.

The statement is too general in that it just says no energy conservation without reference to kinetic energy in particular.

The line about KE1 and KE2 is not sufficient because KE1 and KE2 are not defined and therefore ambiguous – they could just as well refer to a single body before and after the collision as to the whole system.

(a) This collision was inelastic.

State what is meant by inelastic.

(1)

Kinetic energy before collision does not equal kinetic energy after collision.

ResultsPlus Examiner Comments

1 mark.

A simple but sufficient statement that is awarded the mark.

Question 12 (b)

About a quarter of the candidates gained credit here, usually for stating that total momentum before a collision equals the total momentum after the collision. Simply repeating that momentum is conserved added nothing to the information already given and was not credited. The other common credited response referred to a vector triangle, even if there was some ambiguity about whether this was for velocity or momentum.

While candidates sometimes mentioned the equal masses, they rarely explained why this was significant.

(b) For this situation, a scaled vector diagram showing the velocities of the balls can be used to demonstrate the law of conservation of momentum.

Explain why.

(2)

The total ~~velocity (testo~~ momentum in each component (vertical and horizontal) must conserved before and hence after. This way the total energy is conserved and it is shown that no external forces acted on the balls.

ResultsPlus Examiner Comments

0 marks.

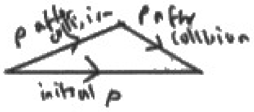
This response refers to total momentum conserved, but the question stem already includes the word 'conservation', so this doesn't add detail to that and so the mark is not awarded.

ResultsPlus Examiner Tip

The explanation of a term cannot rely on the use of the term itself without further detail.

(b) For this situation, a scaled vector diagram showing the velocities of the balls can be used to demonstrate the law of conservation of momentum.

Explain why.



(2)

~~Kinetic energy is a scalar, so components in the x and y are not considered.~~ A scaled vector diagram demonstrating the conservation of momentum will show a closed triangle as the total momentum before the ~~collision~~ collision is equal to the total momentum after the collision. The white and black ball both have the same mass, so the mass does not need to be included in the vector diagram as the masses cancel each other out $p = mv$. so $p \propto v$ when mass is constant

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2 marks.

This is a fairly rare example of a response scoring both marks.

Question 12 (c)

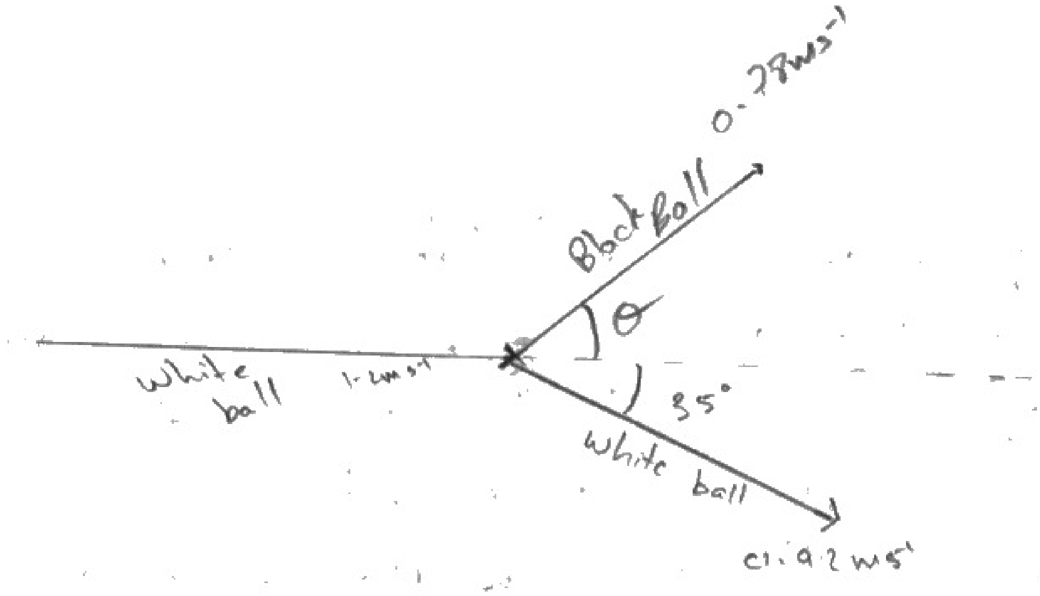
About a third of the candidates did not appear to know how to use a scaled vector diagram and did not attempt one. About a quarter were awarded a single mark for a labelled line with an arrow. The remainder generally included a scale and a good proportion could complete the triangle, although some did not have all of the arrows in the correct directions. Having completed the required diagram, not all candidates made it clear that they were measuring the final angle for their conclusion. Quite a few calculated the final speed but were not able to use it to make the required deduction.

Although the question required use of a scaled diagram, a substantial number of candidates made their deduction by calculation, for example using the cosine rule. They were allowed one mark if they completed this correctly and made the correct conclusion without including any of the diagram.

(c) Deduce whether the black ball moves towards the pocket. You should use a scaled vector diagram.

(5)

0.5cm = 0.1 m s⁻¹



$1.2m = m \times 0.92\cos 35 + m \times 0.78\cos\theta$

$\frac{1}{2}m(1.2)^2 = \frac{1}{2}m(0.92)^2 + \frac{1}{2}m(v)^2$

$v^2 = 1.2^2 - 0.92^2$

$v = 0.78$, $\cos\theta = \frac{1.2 - 0.92\cos 35}{0.78}$, $\theta = 55°$

So the ball doesn't move towards the pocket

(Total for Question 12 = 8 marks)

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Examiner Comments

2 marks.

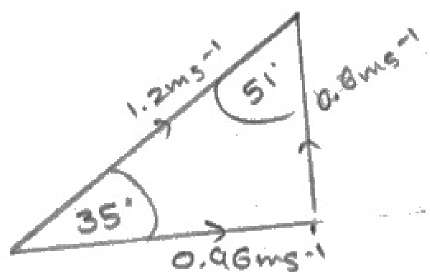
This gets a mark for a labelled vector with a scale, but no more. A vector triangle or parallelogram was required rather than this situational diagram. The final mark could be awarded for deduction by calculation, but this calculation assumes a 90 degree angle between the balls, candidates may be familiar with from elastic collisions between bodies of equal mass. They have already been told, however, that the collision is not elastic.

(c) Deduce whether the black ball moves towards the pocket. You should use a scaled vector diagram.

(5)

$1.2\ ms \rightarrow 4.8cm$

$1\ ms^{-1} = 4cm$



Angle of black ball after collision is 51° at 0.6 ms⁻¹, hence the ball will moves in the direction of the pocket.

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Examiner Comments

4 marks.

This got all the marks but the last one because the final answer is not correct as a result of using 0.96 m s^{-1} instead of 0.92 m s^{-1}.

Question 13 (a)

As well as their knowledge and understanding of linear accelerators, this question assessed candidates' ability to give coherent and logically structured answers, which, in most cases, they did. Many candidates saw this question as an opportunity to give a well-rehearsed description of the operation of linear accelerators according to the mark scheme for similar questions on previous papers but they did not give the wording of this question sufficient attention to see that it actually addressed a different aspect. Accordingly, a large proportion of candidates limited themselves to one or two marks because they explained the situation for the drift tubes rather than for the gaps between them. The answers given for the question in the candidates' heads weren't bad, as far as rote memorisation goes, but they did not explain what was required.

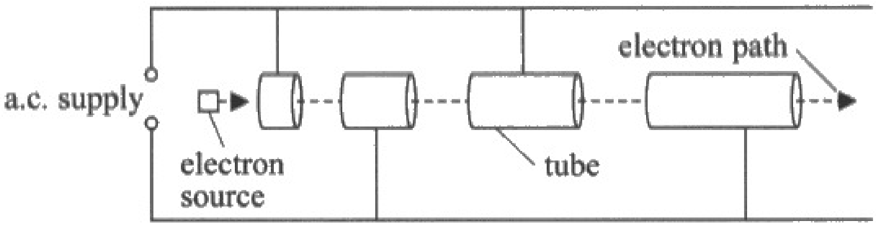
Whether they referred to the tubes or the gaps, there were some common points missing or lacking in detail. Candidates did not always state that the acceleration of the particles takes place in the gaps between the tubes, and some even said they accelerate between the gaps. A large proportion of the candidates refer very simply to electrons being attracted to the next tube by its opposite charge rather than stating that they are accelerated by the electric field between the tubes.

Two of the indicative content points are the same for gaps or tubes and were the most common points credited. Candidates often gained credit for stating that the frequency of the a.c. supply is constant, although some just referred to a constant frequency and didn't say what it was that had a constant frequency. They also often gained credit for electrons approaching the speed of light.

The constant time was often mentioned, although most frequently for the time in the tube rather than between tubes.

Very few candidates were able to address points 4 and 6 in detail, where they were required to link time and speed to the gap length, even though it only required $s = vt$ in addition to what they had already stated.

13 Some particle physics experiments use electrons which are accelerated to very high energies by a linac. The diagram shows the first section of the linac.



*(a) Explain why the distances between consecutive tubes increase in the first section of the linac but are almost equally spaced in the last section of the linac.

(6)

In the first section, the electrons accelerate, ~~so~~ distances between consecutive tubes increase ensure the time of electons spent in each tube are the same, to fit the frequency of a.c. supply, so the electrons can continue accelerate.

In the ~~first~~ last section, the ~~electrons are~~ speed of electrons are close to light speed, the increase in speed is very small, so the time of electrons spent in each tube is almost the same, so distances between consecutive tubes almost equally spaced.

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1 mark.

Like many candidates attempting this question, this candidate's response is focused on the time spent while the electrons are in the drift tubes rather than when they are between them. This does get credit for electrons close to light speed, but that is all. There is no credit for the distance between the tubes being the same at the end because that is already in the question.

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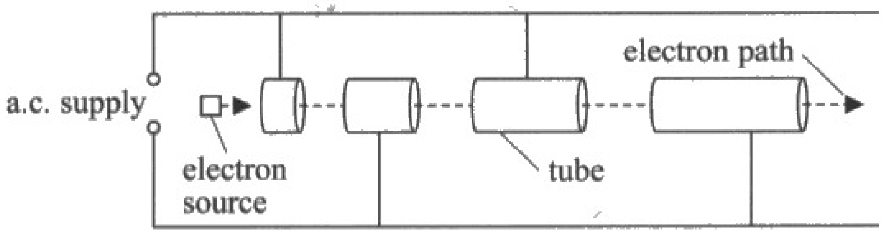
Examiner Tip

While past paper mark schemes can be useful revision aids, questions will not be identical so quoting them directly is unlikely to answer a particular question. Be sure to answer the question on the paper and not a question from a previous paper with a similar situation.

13 Some particle physics experiments use electrons which are accelerated to very high energies by a linac. The diagram shows the first section of the linac.



*(a) Explain why the distances between consecutive tubes increase in the first section of the linac but are almost equally spaced in the last section of the linac.

(6)

- The linac has an a.c supply which alternates the current and hence the polarity of the tubes at a fixed frequency.
- The particle accelerates in the gaps between tubes where the tube behind has the same charge as the particle and the tube in front has the opposite charge. For maximum resultant force.
- As the speed of the particle increases, it traverses a longer distance in unit time, so due to the fixed frequency of the a.c supply, the distance between ~~tubes inc~~ consecutive tubes increase.
- However, the ~~part~~ as the particle approaches the speed of light it cannot be accelerated further so the distance stops increasing.
- Energy required to accelerate a particle then is too impractical

ResultsPlus Examiner Comments

5 marks.

This response is based on the gaps between the drift tubes, as required. It is credited with all of the indicative content points except for the third because it does not make a clear statement that the time spent between the tubes is constant. That gets 3 marks and there are 2 marks for structure because it reads very clearly with fully sustained lines of reasoning.

ResultsPlus Examiner Tip

Learn standard descriptions of situations and physical processes, such as linear accelerators, alpha scattering and electromagnetic induction, and be able apply them with sufficient detail to specific situations, identifying the parts of the general explanation required to answer the particular question.

Question 13 (b)

About half of the candidates gained at least one mark, the most common being for $E = mc^2$ and the next being a comparison of total momentum before and after the collision. While a lot of candidates were familiar with this comparison of collision methods, responses were often missing significant details required for the marks, for example by referring to more energy rather than more kinetic energy. Many candidates just said that the 'inelastic collision' would yield the more massive particles with no indication of which situation they thought was inelastic.

(b) In some experiments, a high-energy electron collides with a stationary atom. In other experiments beams of high-energy electrons, travelling in opposite directions, collide head-on. New particles can be created from collisions.

Deduce which type of collision is more likely to produce new particles with the largest mass.

(3)

When electrons are collided head on all of their energy is used to make new particles Because to create particles ~~to be~~ with large mass alot of energy is required. So momentum before collision = momentum after collision = 0 so all of the energy is used to make new particles. momentum is conserved.

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1 mark.

This gets one mark for describing momentum before and after the head-on collision but nothing else. There is a reference to 'all of the energy' but we need kinetic energy to be discussed specifically. There is no clear conclusion favouring one or the other type of collision.

ResultsPlus Examiner Tip

A non-numerical question asking you to 'deduce whether' still requires a clear conclusion.

(b) In some experiments, a high-energy electron collides with a stationary atom. In other experiments beams of high-energy electrons, travelling in opposite directions, collide head-on. New particles can be created from collisions.

Deduce which type of collision is more likely to produce new particles with the largest mass.

(3)

The momentum of high energy electrons with stationary atoms is non-zero before the collision, so it must be non-zero after the collision. This means some of the energy will be used up for kinetic energy, so there will be less energy available for the formation of mass according to $\frac{E}{c^2} = m$. However, since the electrons are travelling in opposite directions in the other experiments, the have zero total momentum so all the energy released during the collision can be used to produce mass. This is more likely to produce heavier particles.

(Total for Question 13 = 9 marks)

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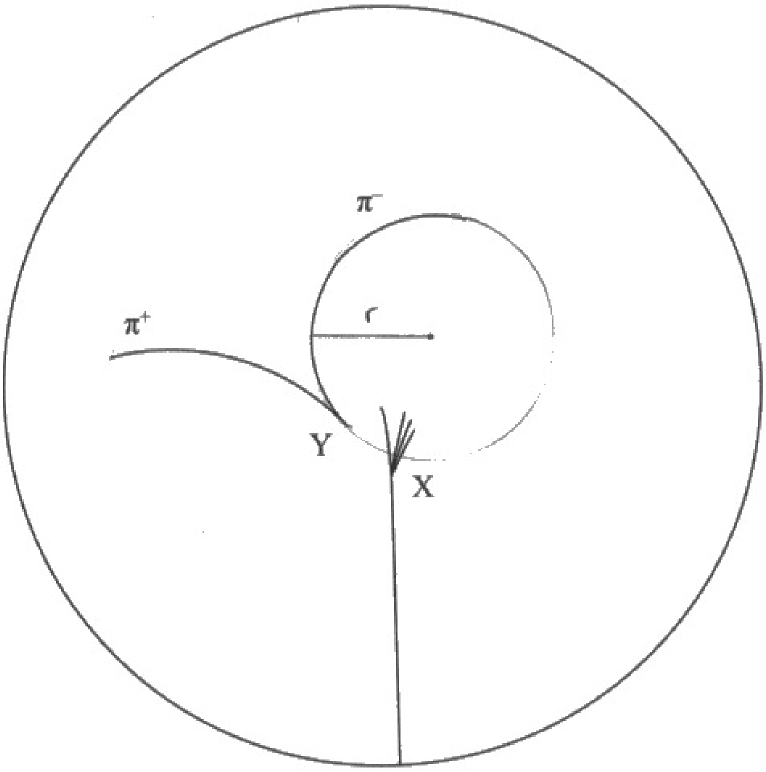
3 marks.

This is awarded full marks for a clear discussion including momentum and kinetic energy, with a clear and well supported conclusion.

Question 14 (a)

About one in three candidates gained full credit for this question and the great majority scored at least one mark. The majority were able to use the diagram to measure a radius within range and to apply the scale. When they achieved this, most candidates were able to apply the equation and calculate the momentum, although some candidates had problems with rearranging the equation. A few candidates did not use the pion charge in coulomb but used the relative charge of –1 instead. Occasionally the final mark was not awarded because the unit was missing.



(a) Determine the momentum of the negative pion.

magnetic flux density of field in the detector = 7.0 T

(4)

r = 1.55 cm
r = 15.5 cm
r = 15.5/100 = 0.155

$r = \frac{P}{BQ}$

$\pi = \frac{1}{3}e = Q$

$0.155 = \frac{P}{7\times(\frac{1}{3}\times 1.6\times10^{-19})}$

$0.155 = \frac{P}{5.33\times10^{-20}}$

$P = 8.3\times10^{-21}$ kgms^{-1}

Momentum = 8.3×10^{-21} kgms^{-1}

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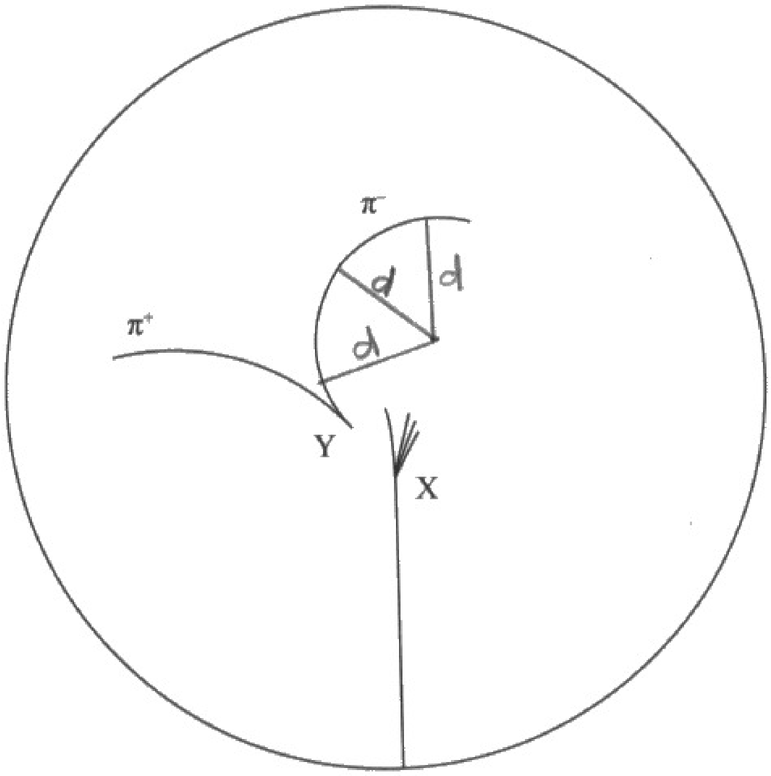
3 marks.

The measurement from the diagram is within range, the scale has been applied and the correct equation has been used. The only problem is that the candidate has decided that a pion has a charge one third that of the electron.



(a) Determine the momentum of the negative pion.

magnetic flux density of field in the detector = 7.0 T

(4)

d = 1.6 cm → x   x = 16 cm

1 cm → 10 cm

$r = \frac{p}{Bq} \Rightarrow p = r \cdot B \cdot q \Leftrightarrow p = 16 \cdot 10^{-2} \cdot 7.0 \cdot 1.60 \cdot 10^{-19}$

$p = 1.792 \cdot 10^{-19}$ kgms^{-1}

$p \approx 1.8 \cdot 10^{-19}$ kgms^{-1}

Momentum = $1.8 \cdot 10^{-19}$ kgms^{-1}

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4 marks.

The candidate has clearly shown how the radius has been determined, although it has been labelled d, and indicated the scaling clearly. The formula has been used correctly and the answer is within range.

Question 14 (b)

Most candidates gained at least one of the marks. The second mark was often attempted but with insufficient detail, for example stating that the pions have opposite charge but not making it clear why this is relevant by reference to conservation of charge.

(b) State two ways that the diagram shows the kaon is neutral.

(2)

1- It doesn't appear with a trail
2- It splits into one negative and one positive particle.

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1 mark.

'It doesn't appear with a trail' is sufficient for the first mark, but 'one negative and one positive' is not enough for the second mark without a comment about charge conservation.

(b) State two ways that the diagram shows the kaon is neutral.

(2)

Kaon's path is ~~not shown~~ not shown in ~~particle~~ circular particle detector which means ~~pt~~ Kaon has no ionisation. Kaon also produces π^+ & π^- which ~~means~~ means ~~overall~~ total charge after decay is zero, so to conserve charge, Kaon must have zero charge as overall charge is zero, so Kaon must be neutral.

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2 marks.

The first two lines are similar to the previous example, but there is a clear reference to the relevance of conservation of charge in the rest of the response.

Question 14 (c)

A minority of candidates gained no credit for this question with about half getting both marks. Incorrect responses often saw the antiproton as ddd and the pion with three quarks.

(c) The table shows the charge for the up quark and the down quark as a fraction of the charge on the proton.

Quark	Charge
u	+2/3
d	–1/3

Deduce the quark structure of the antiproton and the negative pion.

(2)

$\bar{p} = -\frac{1}{3} - \frac{1}{3} - \frac{1}{3}$ → baryon = 3 quarks

$\pi^- = -\frac{2}{3} - \frac{1}{3}$ → meson = 2 quark/antiquark

Quark structure of the antiproton ddd

Quark structure of the negative pion $\bar{u}$ d

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1 mark.

The pion is correct. For the anti-proton the charge is correct, but the candidate has not used anti-quarks.

(c) The table shows the charge for the up quark and the down quark as a fraction of the charge on the proton.

Quark	Charge
u	+2/3
d	–1/3

Deduce the quark structure of the antiproton and the negative pion.

(2)

$\bar{p}^- \rightarrow \bar{u}\bar{u}\bar{d}$ $\pi^- \rightarrow ddd$

Quark structure of the antiproton $\bar{u}\bar{u}\bar{d}$

Quark structure of the negative pion ddd

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Examiner Comments

1 mark.

The anti-proton is correct, but the candidate has given the pion 3 quarks that have a total charge of –1 rather than a quark and an anti-quark.

Question 14 (d)

About half of the entry were awarded full marks. A minority divided by c^2 and multiplied by the electron charge instead of doing the opposite. Some candidates made power of ten errors when converting their calculated eV/c^2, forgetting that giga means 10^9.

u d u

(d) Calculate the mass of a proton in GeV/c^2.

(3)

~~$1.67\times10^{-27} \times 1.6\times10^{2}$~~

$$\frac{1.67\times10^{-27} \times 10^{9} \times 1.6\times10^{-19}}{(3\times10^{8})^{2}} = 2.96\times10^{-54}$$

Mass = 2.96×10^{-54} GeV/c^2

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Examiner Comments

0 marks.

This has been done 'upside-down' as this sequence of operations would have been used for calculating mass in kg.

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Examiner Tip

Practice the conversion from kg to GeV/c^2 and vice versa to be sure to multiply and divide by the correct factors for the different conversions.

(d) Calculate the mass of a proton in GeV/c^2.

(3)

$m_p = 1.67 \times 10^{-27}$ Kg

$E = \Delta mc^2$

$1.67 \times 10^{-27} \times 3 \times 10^8 = 5.01 \times 10^{-19}$ J/c^2

$\rightarrow 3.13$ eV/c^2

$\rightarrow 3.13 \times 10^{-9}$ GeV/c^2

Mass = 3.13×10^{-9} GeV/c^2

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Examiner Comments

0 marks.

The quoted formula has a squared term, but it has disappeared when the formula is applied.

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Examiner Tip

When substituting in an equation with a power term, eg c^2, don't suddenly miss off the index when substituting or forget it in the calculation.

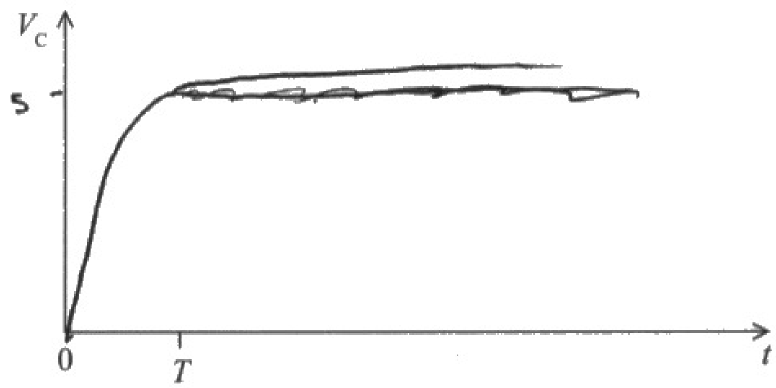
Question 15 (a)(i-ii)

In Q15(a)(i) the graph was rarely completed well. Many candidates drew it as a discharge curve. Others drew what was almost a straight diagonal rapidly curving to level off which did not relate to an exponential function. Another common error was to start at time *T*. The value 5 V was often omitted even when the shape was correct, so that the most common mark awarded was for levelling off after 4 or 5 time constants.

In Q15(a)(ii), of those who said it was an exponential decrease, few added ‘from 5V’ or ‘to 0V’. Candidates did not often explain the decrease by referring to the sum of the p.d.s and, where they did, it was usually written in symbols.

(a) (i) Sketch a graph to show how the potential difference V_C across the capacitor varies with time t as the switch is closed. The time constant T for this circuit is marked on the time axis.

(2)



(ii) Explain how the potential difference V_R across the resistor varies with time after the switch is closed.

(2)

Initially the potential difference across the resistor is 5v but it decreases exponentially until it reaches 0v which is when the potential difference accross the capacitor is 5V

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Q15(a)(i) 1 mark.

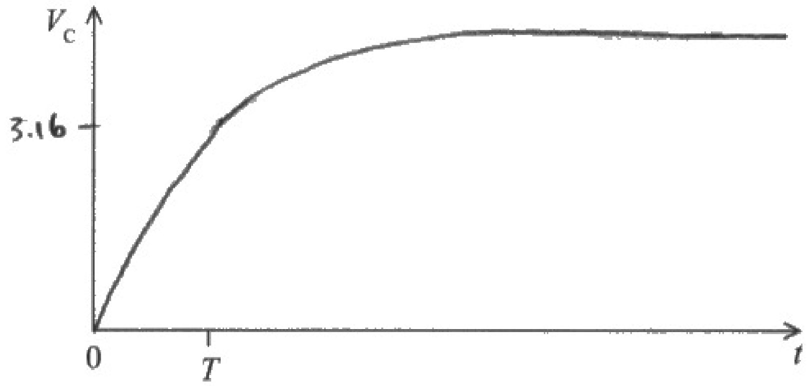
Q15(a)(ii) 1 mark.

Q15(a)(i) – the graph is sufficient, with 5 V marked, for the first mark, but has too steep an increase for the second mark.

Q15(a)(ii) – this gets the first mark for exponential decay from 5 V to 0 V. There is a hint of the second mark, but there is insufficient detail.

(a) (i) Sketch a graph to show how the potential difference V_C across the capacitor varies with time t as the switch is closed. The time constant T for this circuit is marked on the time axis.

(2)



(ii) Explain how the potential difference V_R across the resistor varies with time after the switch is closed.

(2)

• potential difference across ~~capacit~~ resistor decreases exponentially to 0V

$(V_R = V_0 e^{-\frac{t}{RC}})$

• ~~A~~ As $V_C + V_R = V_0$ (constant)

![ResultsPlus Examiner Comments]

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Q15(a)(i) 1 mark.

Q15(a)(ii) 2 marks.

Q15(a)(i) – this graph missed out on the first mark because 5 V wasn't labelled.

Q15(a)(ii) – this is one of the better responses for full marks.

Question 15 (a)(iii)

Only about a quarter of the candidates made much headway with this question, with many merely quoting the equation given with V_0 in place of 5 and then replacing V_0 with 5 again. On the other hand, a number of candidates gave a more detailed proof, starting with the equation for the exponentially decreasing current in the capacitor.

(iii) Show that V_C is given by the equation

$$V_C = 5 - 5e^{-\frac{t}{RC}}$$

where R is the resistance of the resistor
and C is the capacitance of the capacitor.

(2)

$V_c = V_0 - V_0 e^{-t/RC}$ V_0 = initial potential difference

$V_0 = 5V$

$V_c = 5 - 5e^{-t/RC}$

ResultsPlus Examiner Comments

0 marks.

No credit has been given for copying the equation and replacing V_0 with 5 and then reversing it.

(iii) Show that V_C is given by the equation

$V_c = V_0 - V_0 e^{-t/RC}$

$$V_C = 5 - 5e^{-\frac{t}{RC}}$$

$V_0 = I_0 \cdot R$

where R is the resistance of the resistor
and C is the capacitance of the capacitor.

(2)

$EMF = V_c + V_R$

$5 = V_c + V_R$

$V_c = 5 - V_R$

$V_c = 5 - I_0 R$

$V_c = 5 - RI_0 e^{-t/RC}$

$V_c = 5 - V_0 e^{-t/RC}$

$\therefore V_c = 5 - 5e^{-t/RC}$ (shown)

ResultsPlus Examiner Comments

2 marks.

This is well done and justifies the final term in more detail than was usual by referring to the exponentially decreasing current in the charging circuit.

Question 15 (b)

A good majority were able to substitute values into the given equation, but a large number reverted to a simple discharge equation without the initial 5 V. These candidates were only able to gain a mark for taking logs. Candidates who had substituted correctly often had problems with this part because they did not subtract 3.3 V from 5 V first.

Some candidates completed the calculation correctly but did not make a choice of capacitor. Others gave their answer as 4.7 microfarad rather than 4.77 or 4.8 so it was not certain that they had actually carried out the calculation and they were not awarded the final mark.

(b) The input to the integrated circuit should be 3.3 V at a time 3.5 seconds after the switch is closed.

The following capacitors are available:

4.7 μF   10 μF   15 μF   47 μF   150 μF

Deduce which capacitor should be used.

$R = 68\,\text{k}\Omega$

(3)

$3.3 = 5e^{-\frac{3.5}{68\times10^3 C}}$

$\ln 3.3 - \ln 5 = -\frac{3.5}{68000\,C}$ 1.24×10^{-4} F

~~120 uF~~

$-0.4155 = -\frac{3.5}{68000C}$

47 uF

$C = -\frac{3.5}{68000 \times -0.4155}$

ResultsPlus Examiner Comments

1 mark.

In this response the formula used is for the resistor rather than the capacitor. One mark has been allowed for applying logs correctly.

(b) The input to the integrated circuit should be 3.3 V at a time 3.5 seconds after the switch is closed.

The following capacitors are available:

4.7 μF   10 μF   15 μF   47 μF   150 μF

Deduce which capacitor should be used.

$R = 68\,k\Omega$

(3)

$V = 5 - 5e^{-\frac{t}{RC}}$

$3.3 = 5 - 5e^{-\frac{3.5}{68\times10^3 C}}$

$-1.7 = -5e^{-\frac{t}{RC}}$

$0.34 = e^{-\frac{t}{RC}}$

$\ln 0.34 = -\frac{t}{RC}$

$RC = 3.244$

$C = \frac{3.244}{68\times10^3} = 4.77\times10^{-5}\,F = 47\,\mu F$

(Total for Question 15 = 9 marks)

ResultsPlus Examiner Comments

3 marks.

This has been done correctly, although the final conclusion could have been made clearer than just circling the chosen value.

(b) The input to the integrated circuit should be 3.3 V at a time 3.5 seconds after the switch is closed.

Tconst .

The following capacitors are available:

4.7 μF 10 μF 15 μF 47 μF 150 μF

Deduce which capacitor should be used.

$R = 68\,k\Omega$

(3)

$RC_1 = 68 \times 10^3 \times 4.7 \times 10^{-6} = 0.32$. $3.3 = 5 - 5e^{-\frac{3.5}{RC}}$

$RC_2 = 6.8 \times 10^3 \times 10 \times 10^{-6} = 0.68$. $5e^{-\frac{3.5}{RC}} = 1.7$

$RC_3 = 68 \times 10^3 \times 15 \times 10^{-6} = 1.02$ $e^{-\frac{3.5}{RC}} = \frac{1.7}{5}$

$RC_4 = 68 \times 10^3 \times 47 \times 10^{-6} = 3.20$. $-\frac{3.5}{RC} = -1.0788$.

$RC_5 = 68 \times 10^3 \times 150 \times 10^{-6} = 10.2$. $RC = 3.24$.

~~3.5~~ 3.24 is closest to 3.20.

So use 47μF capacitor.

ResultsPlus Examiner Comments

3 marks.

This is an alternative way to determine which capacitor to use. The candidate has determined the time constant value required to give 3.3 V at 3.5 s. They have determined the time constant for each capacitor in series with the resistor, then selected which *RC* value is closest.

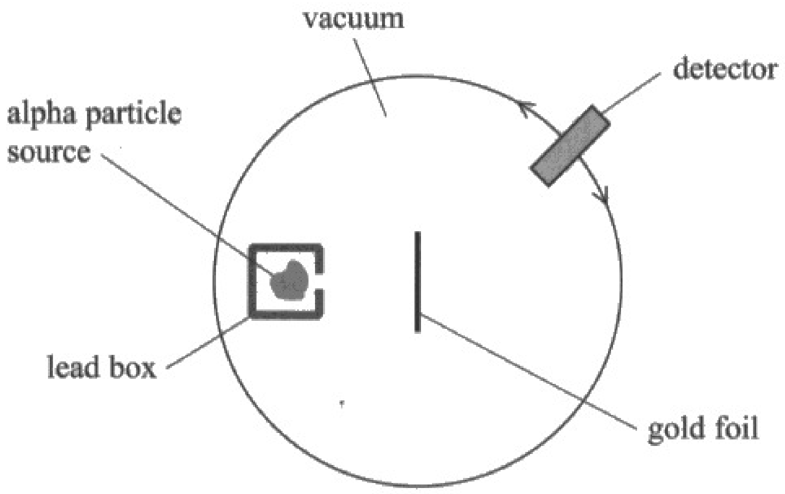
Question 16 (a)

Candidates were clearly familiar with this experiment but did not always include sufficient detail, so the median mark was 3. The great majority referred to most alpha particles passing straight through, although some just said through and some missed most, and these candidates usually gained credit for ‘mostly empty space’. Reference to small angle scattering was not so clear, with a lot writing about large angles up to 90 degrees. Candidates did not always seem to appreciate the small proportion of alpha particles that did not pass straight through and just said ‘some’ rather than ‘few’ or similar. Even so, they usually got the linked conclusion of a concentration of charge, although some said ‘all of the charge’ when it is clearly half of the charge only as it was already known that there is both positive and negative charge. Similarly, the proportion scattering through more than 90 degrees was often called few, rather than ‘very few’ or similar, although the well-known fraction 1 in 8000 was sometimes seen. This third observation was generally linked to a concentration of mass.

Candidates who wrote each observation followed by the corresponding conclusion had more success than those who wrote all of the observations first because for the latter it was harder to link the pairs unambiguously.

16 In the early 20th century, experiments were carried out in which alpha particles were directed towards thin gold foil.

A simplified diagram of the apparatus used is shown.



(a) State three observations and the corresponding conclusions made from the alpha particle scattering experiment.

(6)

· Most alpha particles passed through with no deflection, this shows that most of the foil was empty.

· Some alpha particle were slightly deflected about ~~more~~ ~~then~~ ~~tee~~ 10° - 90° which shows that they were close enough to a charge to feel a force.

· 1 in 8000 alpha particles were deflected more than 90° proving that there is a nucleus with mass and charge in the centre of the ~~fo~~ foil.

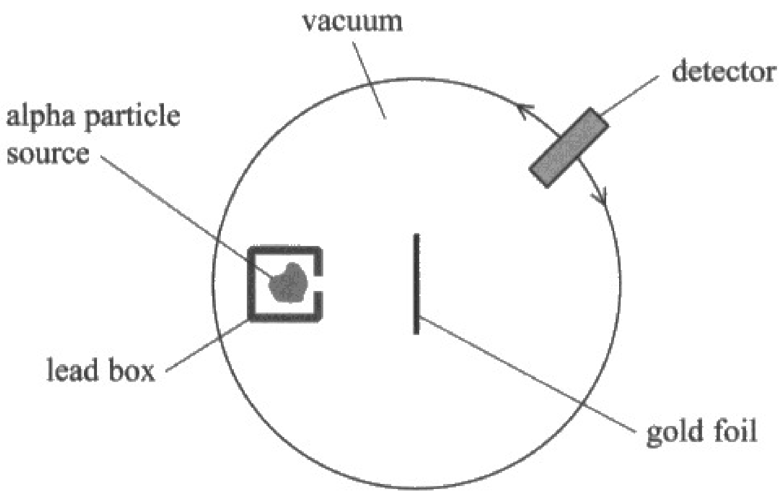
ResultsPlus
Examiner Comments

2 marks.

This gains marks for most alphas with no deflection and 1 in 8000 deflected more than 90 degrees. The first paragraph refers to the foil being empty, rather than atoms. The second says 'some' when we really need to know that it is a relatively small number. 'Most' could be 51%, so 'some' could be as much as 49%. Neither of the final two conclusions have sufficiently correct detail.

16 In the early 20th century, experiments were carried out in which alpha particles were directed towards thin gold foil.

A simplified diagram of the apparatus used is shown.



(a) State three observations and the corresponding conclusions made from the alpha particle scattering experiment.

(6)

Most alpha particles had little to no deflection meaning that the atom consisted mostly of empty space. Some alpha particles deflected in great angles smaller than 90° meaning that there was a concentration of charge in the atoms nucleus. A few alpha particles were deflected in angles greater than 90° meaning that there is a concentration of mass in the center of the atom.

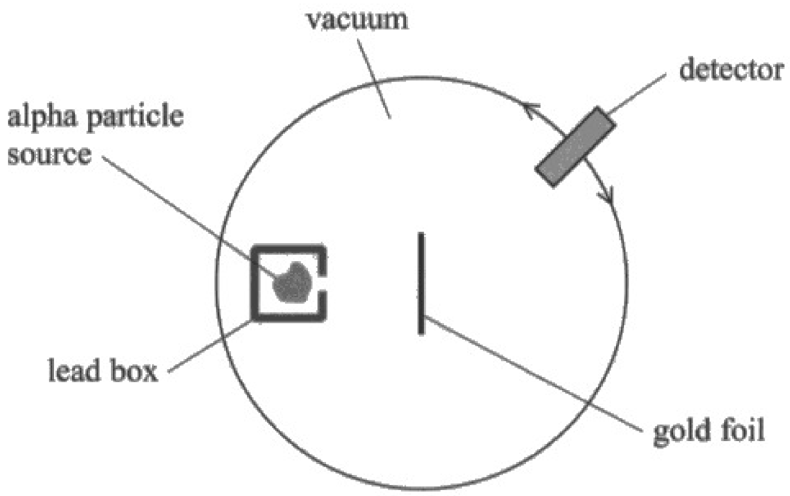
ResultsPlus Examiner Comments

4 marks.

This is a typical 4 mark question that misses the other 2 marks by not describing the small fraction of the alpha particles scattered through larger angles.

16 In the early 20th century, experiments were carried out in which alpha particles were directed towards thin gold foil.

A simplified diagram of the apparatus used is shown.



(a) State three observations and the corresponding conclusions made from the alpha particle scattering experiment.

(6)

• the vast majority of alpha particles went straight through the foil with no deflection

• this means that most of the atom is empty space.

• a few alpha particles were deflected at angles less than 90°

• there is a structure within an atom that has a lot of positive charge concentrated there.

• very very few alpha particles were deflected ~~by~~ at angles more than 90°

• the charged structure has nearly all of the mass of the atom in a very small area compared to the area of the entire atom

ResultsPlus
Examiner Comments

6 marks.

This is an example of a full mark response. Note the use of 'most', 'few' and 'very few'.

Question 16 (b)(i-ii)

In Q16(b)(i) nearly all candidates successfully converted MeV to J. A lot of candidates then tried to make use of the equation for radial electric field strength, confusing E for energy. Another incorrect method was the use of Coulomb’s law with various ways of trying to calculate the force and apply it to the kinetic energy equation. Those candidates realising they needed to use $V = kQ/r$ usually combined it with $W = QV$ into one equation to proceed to the correct answer. Some candidates omitted one or both of 2 and 79 for the charge of the helium and gold nuclei respectively.

Q16(b)(ii) was generally well answered, but some tried to use $E = V/d$, mistaking E for electric field with E for energy and substituting their value of 4.7MeV in J.

(b) One experiment used gold foil made from the gold isotope $^{197}_{79}Au$. The alpha particles had an initial kinetic energy of 4.7 MeV.

(i) Show that the closest distance these alpha particles can get to a gold nucleus is about 5×10^{-14} m.

(4)

4.7 MeV → 4.7×10^6 eV → 7.52×10^{-13} J

1 eV → 1.6×10^{-19} J

$$F = \frac{(79 \times 1.6\times10^{-19}) \times (2 \times 1.6\times10^{-19})}{4 \pi \varepsilon_0 \times r^2}$$

$W = F \times d$

$7.52 \times 10^{-13} = 0.5 \times (1.67\times10^{-27})^2 \times v^2$

(ii) Calculate the strength of the electric field due to the gold nucleus at this distance.

(3)

$$E = \frac{79 \times 1.6\times10^{-19}}{4 \times \pi \times 8.85\times10^{-12} \times (5\times10^{-14})^2}$$

$= 4.55 \times 10^{19}$

Strength of electric field = 4.55×10^{19}

ResultsPlus
Examiner Comments

Q16(b)(i) 1 mark.

Q16(b)(ii) 2 marks.

Q16(b)(i) – the conversion from MeV to J is correct, but then the candidate uses the equation for Coulomb force rather than for electric potential.

Q16(b)(ii) – the calculation is correct, using the 'show that' value, but the unit has been omitted, so the final mark has not been awarded.

ResultsPlus
Examiner Tip

Physical quantities have a magnitude and a unit and both must be given in answers to numerical questions.

(b) One experiment used gold foil made from the gold isotope $^{197}_{79}$Au. The alpha particles had an initial kinetic energy of 4.7 MeV. 2

(i) Show that the closest distance these alpha particles can get to a gold nucleus is about 5×10^{-14} m.

(4)

$4.7 \times (1.6 \times 10^{-13}) = 7.52 \times 10^{-13}$ J

$V = \frac{E}{Q}$, $V = \frac{Q}{4\pi\varepsilon_0 r}$

$\therefore \frac{Q_1}{4\pi\varepsilon_0 r} = \frac{E}{Q_2}$ $\quad \therefore \frac{Q_1 \times Q_2}{E \times 4\pi\varepsilon_0} = r$ $\quad r = \frac{(79 \times 1.6 \times 10^{-19}) \times (2 \times 1.6 \times 10^{-19})}{7.52 \times 10^{-13} \times 4\pi \times (8.85 \times 10^{-12})}$

$r = 4.84 \times 10^{-14}$ m $\approx 5 \times 10^{-14}$ m

(ii) Calculate the strength of the electric field due to the gold nucleus at this distance.

(3)

$E = \frac{79 \times (1.6 \times 10^{-19})}{4\pi (8.85 \times 10^{-12}) \times (4.84 \times 10^{-14})^2} = 4.85 \times 10^{19}$ N C^{-1}

Strength of electric field = 4.85×10^{19} NC^{-1}

ResultsPlus
Examiner Comments

Q16(b)(i) 4 marks.

Q16(b)(ii) 3 marks.

This is an example of a response gaining full marks.

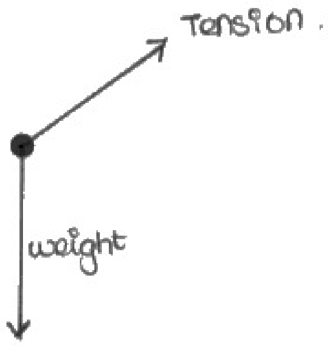
Question 17 (a)(i)

About half of all candidates gained both marks and most of the rest were awarded one mark, usually for weight as they drew tension diagonally upwards, in the opposite direction to that required. These diagrams looked like those expected for a conical pendulum. Some candidates did not get the mark for weight because they labelled it as *g* or gravity. A few added a third horizontal force labelled centripetal, which was an incorrect addition as that would be a resultant force rather than a separate force. This did demonstrate a general misunderstanding of the situation because the incorrectly added centripetal force, when seen, was not in the direction of the resultant force.

(a) (i) The tension in the chain, acting on the sphere, is T.

Draw the free-body force diagram for the sphere at the position shown in the diagram.

(2)



ResultsPlus
Examiner Comments

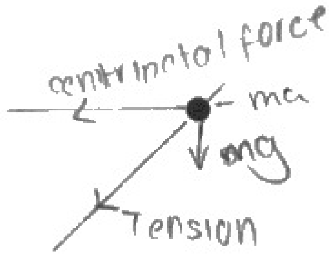
1 mark.

This is a free-body force diagram for the sphere, but the tension has been drawn here in the opposite direction to the correct one, as if it is the force acting on the athlete's hand.

(a) (i) The tension in the chain, acting on the sphere, is T.

Draw the free-body force diagram for the sphere at the position shown in the diagram.

(2)



ResultsPlus
Examiner Comments

1 mark.

Tension and weight are correct, but a force labelled centripetal has been added as well, even though it should be the resultant of the other forces.

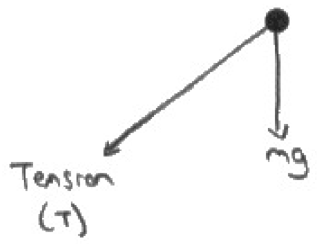
ResultsPlus
Examiner Tip

'Centripetal force' is not a separate particular type of force but the resultant of the forces acting in a situation that results in circular motion.

(a) (i) The tension in the chain, acting on the sphere, is T.

Draw the free-body force diagram for the sphere at the position shown in the diagram.

(2)



ResultsPlus
Examiner Comments

2 marks.

This is a correct diagram for comparison.

Question 17 (a)(ii)

Only about one in ten candidates seemed to understand that it is the resultant force that acts as a centripetal force, with the majority of candidate talking about components of tension and/or weight acting at 90 ° to the motion, probably thinking of a conical pendulum.

(ii) Explain why the sphere moves with circular motion.

(2)

The sum of the horizontal vectors components of tension and weight will create a centripetal force which prevents the ball from moving along a straight path, and forces it into circular motion.

ResultsPlus Examiner Comments

0 marks.

This candidate is assuming that the path of the sphere is in the horizontal plane, like a conical pendulum.

(ii) Explain why the sphere moves with circular motion.

(2)

the sphere has horizontal velocity, the horizontal component of tension is a resultant force perpendicular to the direction of motion. ∴ the component of tension is a centripetal force causing acceleration towards the centre.

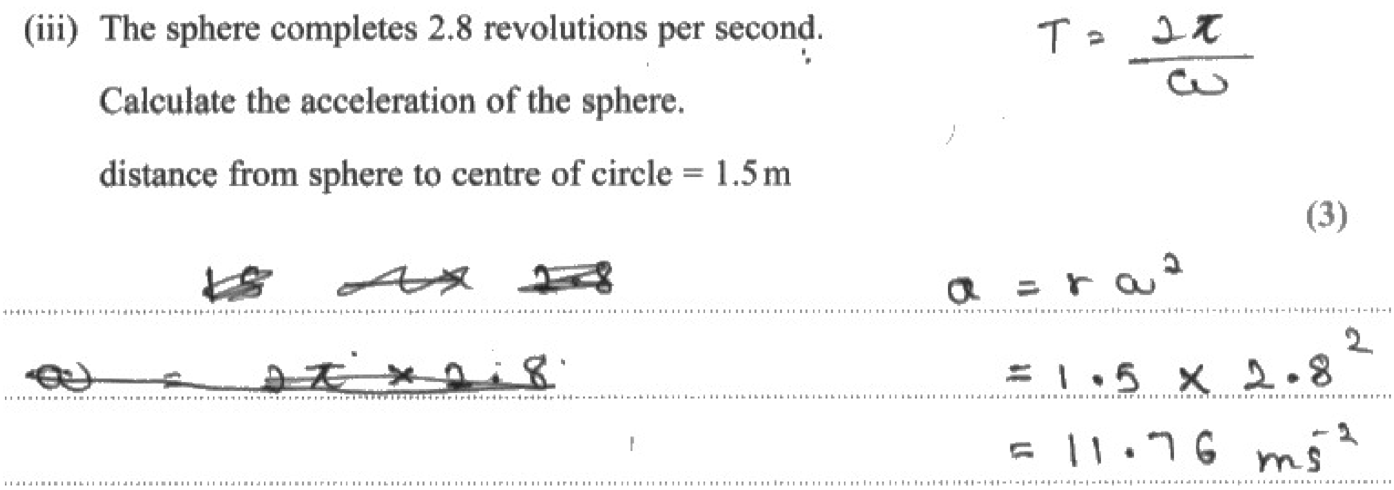
ResultsPlus Examiner Comments

1 mark.

Although a lot of the rest is incorrect, in this response the credit is for stating that there is a resultant force perpendicular to the direction motion.

Question 17 (a)(iii)

The majority of candidates completed this successfully for 3 marks. A common error for the others was to take the frequency of 2.8 revolutions per second as the time period. A few candidates halved the radius given in the data. Some candidates dropped the square partway through their working and the unit of speed was sometimes given rather than the unit of acceleration.



(iii) The sphere completes 2.8 revolutions per second.

Calculate the acceleration of the sphere.

distance from sphere to centre of circle = 1.5 m

(3)

$T = \frac{2\pi}{\omega}$

~~1.8 4 × 2.8~~

~~$\omega = 2\pi \times 2.8$~~

$a = r\omega^2$

$= 1.5 \times 2.8^2$

$= 11.76\ ms^{-2}$

ResultsPlus
Examiner Comments

0 marks.

A lot of candidates used 2.8 incorrectly. In this response it has been used as angular velocity.

(iii) The sphere completes 2.8 revolutions per second.

Calculate the acceleration of the sphere.

distance from sphere to centre of circle = 1.5 m

(3)

$a = r.w^2$ $T = \frac{1}{f} = \frac{1}{2.8}$

$T = \frac{2\pi}{w}$

$a = (1.5)(\frac{28}{5}\pi)^2$

$w = \frac{2\pi}{T} = \frac{28}{5}\pi$ $a = 464.27$

Acceleration = $464.3 \, ms^{-1}$

ResultsPlus
Examiner Comments

2 marks.

The calculations are correct, but the final unit is for speed rather than for acceleration.

Question 17 (b)

About a fifth of the candidates were able to work this through to the end and draw a valid conclusion. Nearly all candidates were able to take components, and many could use an equation of motion and use s = vt.

A common error was to fail to take into account the initial height of 1.5 m above the ground. Some candidates used the centripetal acceleration they had calculated for the sphere. Some attempted to use conservation of energy, forgetting that the sphere still had kinetic energy at the top of its path.

(b) The athlete finally releases the sphere with a velocity of $28\,m\,s^{-1}$ at an angle of 40° to the horizontal. She releases the sphere at a height of 1.5 m above the ground.

The women's Olympic record distance for the hammer throw is 83 m.

Deduce whether this throw would break the record.

(5)

Assuming a closed system with no external resistive force

vertical velocity, $u_T = 28 \times \sin 40° = 17.998\ ms^{-1}$

horizontal velocity, $u_H = 28 \times \cos 40° = 21.449\ ms^{-1}$

∴ Constant downward acceleration, $g = -9.81\ ms^{-2}$

∴ Total time spent in air, t

~~$(V_T)^2 = (u_T)^2$~~ $s = u_T t + \frac{1}{2} g t^2$

∴ $1.5 = (17.998)t + \frac{1}{2}(-9.81)t^2$

$4.905t^2 - 17.998t + 1.5 = 0$, Solving this quadratic equation

$t = 3.583\ s$ $t = 0.0853$ is rejected.

∴ Horizontal distance travelled, $s_H = (21.449) \times (3.583) = 76.85\ m$

Since 76.85 m < 83 m, the throw would NOT break record.

(Total for Question 17 = 12 marks)

ResultsPlus
Examiner Comments

3 marks.

This is very nearly correct but for a missing minus sign. This method assumes that the sphere ends up 1.5 m above its launch height rather than below it. There is a clear comparison and conclusion, but this is only credited if the values are correct.

ResultsPlus
Examiner Tip

Where you are asked to come to a conclusion by command words such as 'deduce whether' using numerical data, you must complete your calculations, then explicitly compare the relevant values and then make a clear statement in conclusion – 'Calculate, Compare, Conclude'.

(b) The athlete finally releases the sphere with a velocity of $28\,m\,s^{-1}$ at an angle of 40° to the horizontal. She releases the sphere at a height of 1.5 m above the ground.

The women's Olympic record distance for the hammer throw is 83 m.

Deduce whether this throw would break the record.

(5)

$s = -1.5$

$s = ut - \frac{1}{2}gt^2$

$-1.5 = 28(\sin 40)t - \frac{g}{2}t^2$

$t = 3.730858615$ or $t = -0.0815$ (rej.)

Distance thrown $= 28\cos 40(t) = 80.45308317\,m = 80.5\,m$

$\because 80.5 < 83$

$\therefore$ will not break the record.

ResultsPlus
Examiner Comments

5 marks.

Candidates using this 'one-step' approach to time found the calculation quite straightforward. There is a clear comparison of values and conclusion, as required when a numerical question says 'deduce whether'.

Question 18 (a)(i-ii)

In Q18(a)(i) the great majority of candidates completed this successfully, although a few did not give their final answer to the required 2 s.f. for this 'show that' question where the required quantity was stated to 1 s.f.

In Q18(a)(ii) the majority of candidates gained full marks for this part, using their previous value for momentum or for speed. The percentage part caused more difficulty than the physics, with a fair few using 10% instead of 90%. A few struggled with rearrangement or omitted the square root.

(a) (i) The vehicle was given a push. The aluminium plate took 0.19 s to pass through light gate 1.

Show that the momentum of the vehicle was about 0.3 N s.

$v = \frac{d}{t}$

length of plate = 15.0 cm
mass of vehicle = 0.40 kg

(3)

~~m = P × V~~

$p = m \times v \rightarrow 0.40 \times \left(\frac{15 \times 10^{-2}}{0.19}\right) = 0.31\ Ns$

(ii) The vehicle then moved between the poles of the magnet before passing through light gate 2.

The magnet caused the kinetic energy of the vehicle to reduce by 10%.

Calculate the velocity of the vehicle at light gate 2.

(3)

$k.e = \frac{v^2}{2m}$ $\quad \frac{1}{2} \times 0.40 \times \left(\frac{15 \times 10^{-2}}{0.19}\right)^2 = 0.1246\ J$

$0.1246 \times \frac{10}{100} = 0.01246$

$ke = 0.11214$ $\quad ke = \frac{v^2}{2m}$

$\frac{0.11214}{2 \times 0.40} = v^2 \rightarrow \sqrt{\frac{0.11214}{2 \times 0.40}}$

Velocity = 0.37 m/s^{-1}

ResultsPlus
Examiner Comments

Q18(a)(i) 2 marks.

Q18(a)(ii) 2 marks.

Q18(a)(i) – the final answer has been truncated to 0.31 Ns which is not acceptable because the calculated answer is 0.3158 Ns.

Q18(a)(ii) – there is a clear calculation of the initial kinetic energy and determination of the final kinetic energy, but not the final velocity.

(a) (i) The vehicle was given a push. The aluminium plate took 0.19 s to pass through light gate 1.

Show that the momentum of the vehicle was about 0.3 N s.

length of plate = 15.0 cm
mass of vehicle = 0.40 kg

(3)

$\frac{1.5\times10^{-3}}{0.19}$ = ~~7.8947 x10^-3 m/s~~ 0 .789 m/s.

0.789 x 0.4 = 0.3 N/s.

(ii) The vehicle then moved between the poles of the magnet before passing through light gate 2.

The magnet caused the kinetic energy of the vehicle to reduce by 10%.

Calculate the velocity of the vehicle at light gate 2.

(3)

~~0.739 × 10/100 = 0.0739~~ ~~0.739 − 0.0739~~

~~= 0.7101~~ $\frac{1}{2} \times 0.4 \times (0.739)^2 = 0.1245\ J$

$0.1245 \times \frac{10}{100} = 0.012\ J$ | $0.1245 - 0.012 = 0.1125$

$\sqrt{\frac{2(0.112)}{0.4}} = v$ | $v = 0.75\ m/s$

Velocity = 0.75 m/s.

ResultsPlus
Examiner Comments

Q18(a)(i) 2 marks.

Q18(a)(ii) 3 marks.

Q18(a)(i) – the answer has been given as 0.3 Ns, which is the same as the 'show that' value in the question and does not have the required additional significant figure.

Q18(a)(ii) – this is fully correct.

ResultsPlus
Examiner Tip

When a calculation question starts with 'show that', you are required to give your final answer to at least one additional significant figure.

Question 18 (b)(i)

About half of the candidates were awarded 2 marks, aided by having three marking points that could be credited. Most answers referred to all three points, but not always in sufficient detail, particularly relating to the change in flux linkage where they frequently omitted 'linkage' or 'lines'.

(b) (i) Explain why a current was produced in the aluminium plate as it passed between the poles of the magnet.

(2)

Emf is produced to the change of flux $Emf = \frac{NAB}{t}$

ResultsPlus
Examiner Comments

0 marks.

This is only 2 words away from 2 marks. Emf should be 'induced' rather than 'produced' and it should be the change in flux 'linkage'.

(b) (i) Explain why a current was produced in the aluminium plate as it passed between the poles of the magnet.

(2)

~~ma~~ when the plate passed through the magnet there was a change in ~~mag~~ flux linkage which induced e.m.f. and since the plate is a closed circuit current was induced

ResultsPlus
Examiner Comments

2 marks.

There were three possible marking points and this response has all three, being awarded 2 marks.

Question 18 (b)(ii)

About a third of the candidates made relevant comments in their answers. Most tried to explain using Lenz's law, but often applied it to opposing the induced emf rather than a force opposing the plate's motion. Few candidates attempted to explain the origin of the force in terms of the motor effect.

(ii) The kinetic energy of the vehicle decreased as the aluminium plate moved between the poles of the magnet.

Explain why.

(2)

due to lenz law, the current induced in the plate will form its own magnetic field which will oppose the original motion of aliminium plate passing through the magnet towards left so energy gets transferred from kinetic energy to electrostatic energy

ResultsPlus Examiner Comments

0 marks.

The statement about the magnetic field opposing the motion is not sufficient without reference to force.

(ii) The kinetic energy of the vehicle decreased as the aluminium plate moved between the poles of the magnet.

Explain why.

(2)

There is a current in a magnetic field so a force. According to lenze's law the force works to reduce the change in magnetic flux, so it opposes motion. Force that opposes motion means a decreas in kinetic energy.

ResultsPlus Examiner Comments

2 marks.

This is a relatively rare example of a full mark response including all the relevant points.

Question 18 (c)(i)

There were many possible approaches to this question and the great majority of candidates used one of them to gain 2 marks.

(i) Show that the percentage reduction in kinetic energy is proportional to the thickness of the plate.

(2)

$\frac{22}{1.1} = \frac{16}{0.8} = \frac{10}{0.5}$

This means that as the thickness increases, the percentage reduction will always be proportional to double the thickness %R ∝ 2T

ResultsPlus Examiner Comments

0 marks.

This is a relatively rare non-scoring response. Candidates were required to calculate an appropriate ratio. This candidate has just written down the three ratios and stated that they are equal without performing any calculations to justify that.

(i) Show that the percentage reduction in kinetic energy is proportional to the thickness of the plate.

(2)

$\frac{0.1}{0.5} = \frac{1}{5}$

$\frac{0.16}{0.8} = \frac{1}{5}$

$\frac{0.22}{1.1} = \frac{1}{5}$

∴ Percentage Reduction ~~thickness~~ is ~~propt~~ proportional to thickness

ResultsPlus
Examiner Comments

2 marks.

This is one of a wide range of successful approaches. Note that this candidate has converted the percentage reduction in KE values to decimal numbers before calculating the ratios.

Question 18 (c)(ii)

Only a small proportion of the candidates described an increased current caused by decreased resistance. Most candidates mistook increasing thickness for increasing length or width, leading them to write about increased rate of change of flux linkage, due to an increased area, and therefore increased induced emf. Some candidates wrote about increased numbers of charge carriers without linking this to decreased resistance.

(ii) Suggest why the percentage reduction in kinetic energy increases as the thickness of the plate increases.

(3)

The cross section area increases and ~~as~~ the magnetic flux linkage increases as well.

emf = $-N\left(\frac{d\phi}{dt}\right)$ where $\phi = BA$ / A = area of cross section. As the Area of Cross section increases, emf induced ~~increases~~ as well which results in greater repulsion from the magnets to the glider. due to stronger ~~oppos~~ flux linkage. / more e.m.f → more counter pole strength opposing magnetic field density higher.

(Total for Question 18 = 15 marks)

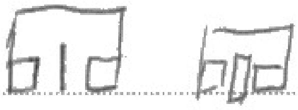
ResultsPlus
Examiner Comments

0 marks.

This is a detailed response, but the thickness of the plate does not affect the area of the plate linked with the magnetic flux, so it is based on an incorrect assumption.

(ii) Suggest why the percentage reduction in kinetic energy increases as the thickness of the plate increases.

(3)



$e.m.f. = \frac{-d(NBA)}{dt}$. Cross sectional area increases so there is a greater e.m.f. And resistance decreases ~~increases~~. $\frac{V}{R} = I$ so current increases and $F = BIl\sin\theta$ so force increases. So loss in kinetic energy ~~decreases~~ increases so percentage reduction increases.

ResultsPlus
Examiner Comments

1 mark.

This response includes a reference to decreased resistance due to increased cross-sectional area, for 1 mark. The mark for increased current has not been awarded as it has been attributed to increased emf.

Paper Summary

Based on their performance on this paper, candidates should:

- show all steps and substitutions clearly in derivations and start from standard basic formulae.
- address all points specifically mentioned in questions, such as the use of a scale diagram.
- learn standard descriptions of physical processes, and required procedures, such as linear accelerators, and be able to apply them with sufficient detail to specific situations, identifying the parts of the general explanation required to answer the particular question.
- note that when substituting in an equation with a power term, eg square root, don’t forget it in the calculation.
- be sure to know the standard SI prefixes and be able to apply the correct power of ten.
- remember that there are no extra marks for completing multiple choice questions ‘in your head’, so candidates should be ready to write them out on the paper.
- be sure you know the command words and understand the level of required response for each of them, eg 'explain' would mean a candidate must say why something happens and not just describe what happens. There will always be at least two linked marking points for a question asking you to ‘explain’.

Grade boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

https://qualifications.pearson.com/en/support/support-topics/results-certification/grade-boundaries.html

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