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June 2025

Int Advanced Level Physics WPH14 01

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June 2025

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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 several 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 using an exponential equation or applying conversions between mass in GeV/c2 to kg in a linac. They also knew some significant points in explanations linked to standard situations, such as electromagnetic induction and accelerators, and could generally set out their ideas in a logical sequence but could not always identify which points were most relevant for a particular context, even when it was a familiar one. There was also a lack of specific detail in answers, such as explaining how momentum was conserved in a bubble chamber.

Steady improvement was demonstrated in all 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.

Question 11(a)

This was a straightforward question to begin the exam. The vast majority of candidates scored full marks. A small number of candidates did not know the charge of a proton and were unable to progress. Some lost a mark for adding incorrect or missing units, as the omission of a unit typically incurs a one-mark penalty on most clips. Others made powers-of-ten errors, which also resulted in a one-mark deduction.

(a) The proton experiences a force of 6.5×10^{-13} N due to the magnetic field.

Calculate the speed of the proton.

magnetic flux density = 0.52 T

(2)

$F = BQV$

$\frac{F}{BQ} = V$

$\frac{6.5 \times 10^{-13}}{0.52 \times 1.6 \times 10^{-19}} = 78.125 p\ m^{-2} s^{-1}$

Speed = $78.125 p\ m^{-2} s^{-1}$

ResultsPlus
Examiner Comments

This candidate had made both a power of ten error and a unit error. In which case they are only penalised once, one mark.

ResultsPlus
Examiner Tip

Work in standard units and write numbers exactly as they appear on your calculator (correctly rounded if needed). Always include the correct units for every value. Avoid using multipliers – for example, this candidate may have meant to write Mm.

(a) The proton experiences a force of 6.5×10^{-13} N due to the magnetic field.

Calculate the speed of the proton.

magnetic flux density = 0.52 T

(2)

$F = Bqv$

$6.5 \times 10^{-13} = 0.52 \times 1.6 \times 10^{-19} \times v$

$v = 7.81 \times 10^{6}\ ms^{-1}$

Speed = $7.8 \times 10^{6}\ ms^{-1}$

ResultsPlus
Examiner Comments

This is a typical fully correct answer.

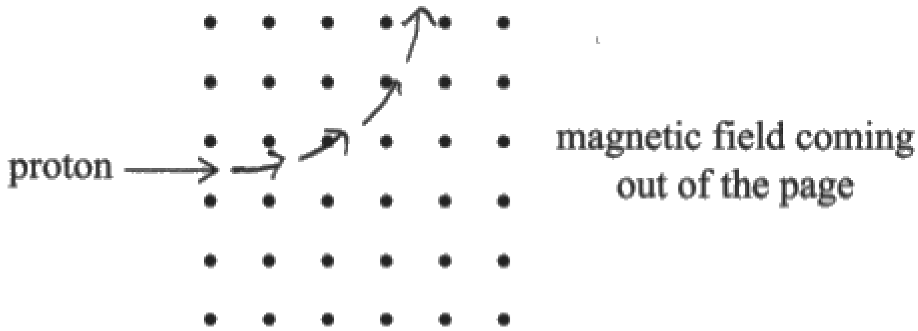
Question 11(b)

Candidates were asked to draw a proton's path in a magnetic field. A clockwise curve towards the bottom of the page was required. The only concept being tested here was Fleming's Left-Hand Rule (FLHR); no context (eg a bubble chamber) was provided, so a range of shapes and spiral paths were accepted. Most candidates got the first mark but only just over half achieved the second.

For the first mark, any curved line was accepted.

For the second mark, the curve needed to be both downward and clockwise.

This candidate had the direction of the proton incorrect. One arrow on a continuous line would have sufficed — drawing multiple arrows is unnecessary.



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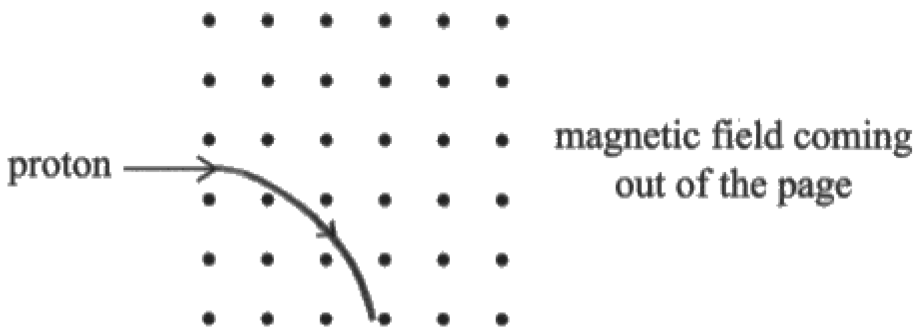
Examiner Comments

This candidate scored 1 out of 2 marks.



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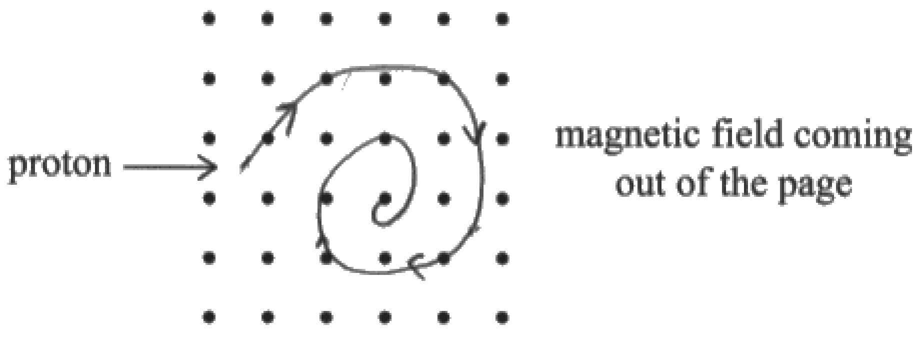
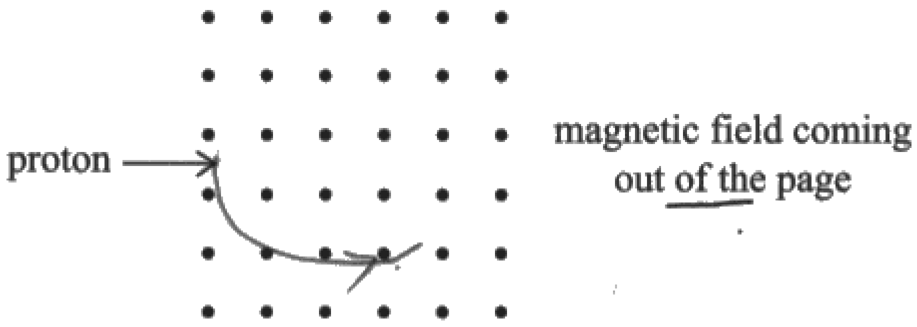
Examiner Comments

This was a perfect answer, full marks.



ResultsPlus
Examiner Comments

This candidate did not draw a downwards curve and therefore lost the second mark.



ResultsPlus
Examiner Comments

This candidate scored only the first mark because the curve was not drawn clockwise.

Question 12

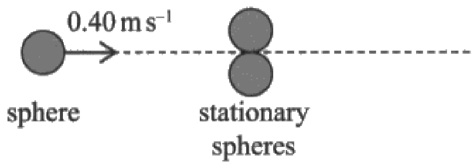
In this question the candidates had to use conservation of momentum to calculate the angle between two spheres after a collision.

The vast majority scored the first mark for using the momentum equation. Those who did not score this mark often mistakenly assumed that velocity is conserved.

The second mark was awarded for using the correct masses and clearly indicating that momentum was conserved.

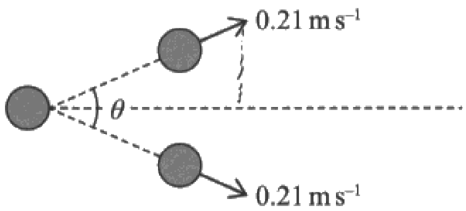
The final mark was achieved by about half the candidates - a common error was forgetting to double the angle.

12 A student investigated collisions, using three spheres. The student rolled a sphere of mass 35 g into two stationary spheres, each of mass 37 g, as shown.



During the collision, the rolling sphere was brought to rest and the two stationary spheres began to move apart at an angle θ, as shown below.

Not to scale



Determine the angle θ.

$0.4\,m = 0.21 \times \cos\frac{\theta}{2} \times 2m$

$\cos\frac{\theta}{2} = \frac{0.4}{0.21 \times 2} = \frac{20}{21}$

So $\frac{\theta}{2} = 17.75°$

$\theta = 35.5°$

$\theta =$ 35.5°

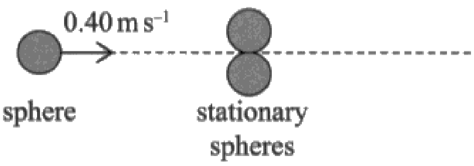
ResultsPlus Examiner Comments

This candidate only achieved the mark for use of momentum - p = mv

ResultsPlus Examiner Tip

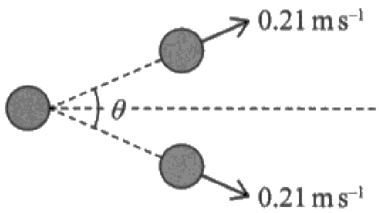
Remember, only certain quantities are conserved – momentum is conserved but not velocity.

12 A student investigated collisions, using three spheres. The student rolled a sphere of mass 35 g into two stationary spheres, each of mass 37 g, as shown.



During the collision, the rolling sphere was brought to rest and the two stationary spheres began to move apart at an angle θ, as shown below.

Not to scale



Determine the angle θ.

$0.4 \times 0.035 = 2 \times 0.21 \times 0.037 \times \cos\left(\frac{\theta}{2}\right)$

$\cos\left(\frac{\theta}{2}\right) = 0.9009$

$\frac{\theta}{2} = 25.723$

$\theta = 51.447 \approx 51.4$

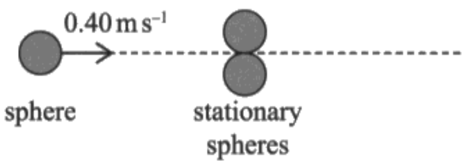
$\theta =$ 51.4

ResultsPlus
Examiner Comments

This candidate had everything correct but omitted the unit. This candidate only scored 2 out of 3 marks.

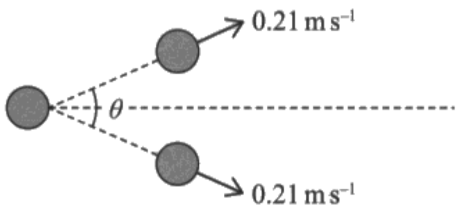
A common error was finding only half the angle between the spheres.

12 A student investigated collisions, using three spheres. The student rolled a sphere of mass 35 g into two stationary spheres, each of mass 37 g, as shown.



During the collision, the rolling sphere was brought to rest and the two stationary spheres began to move apart at an angle θ, as shown below.

Not to scale



Determine the angle θ.

momentum before: $0.4 \times 35 \times 10^{-3} =$

$= 0.014\ \text{kg m s}^{-1}$

$2 \times 0.21 \times 37 \times 10^{-3} \times \cancel{\sin} \cos\theta = 0.014$

$\cos\theta = \dfrac{0.014}{2 \times 0.21 \times 37 \times 10^{-3}} = \dfrac{100}{111}$

$\theta = \arccos\left(\dfrac{100}{111}\right) = 25.7°$

$\theta =$ 25.7°

ResultsPlus
Examiner Comments

This only scored 2 out of 3 marks.

Question 13

This question required a straightforward application of the equation

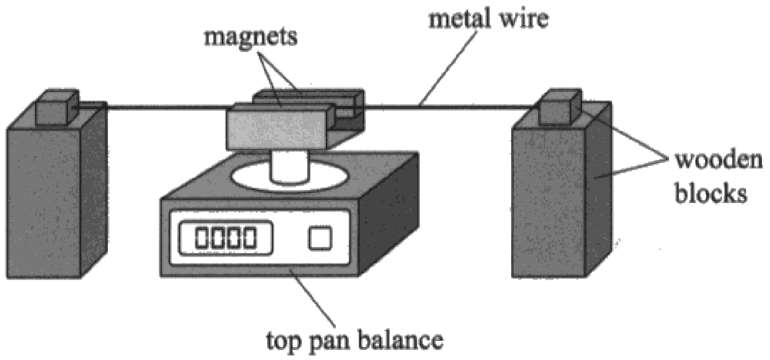
$F = BIL \sin \theta$

The majority of candidates achieved full marks.

A common reason for not gaining full marks was either omitting the unit or providing an incorrect one. Another common error was a power-of-ten mistake when converting grams to kilograms.

This candidate converted to metres correctly but forgot to convert grams to kilograms.

13 A student placed two magnets on a top pan balance. The student clamped a metal wire horizontally in the uniform magnetic field between the magnets, as shown.



The student connected the ends of the metal wire to a battery, an ammeter and a switch.

When the switch was closed, the reading on the ammeter was 3.1 A. The reading on the balance increased by 0.45 g.

The length of the metal wire in the magnetic field was 40 mm.

Calculate the magnetic flux density in the region between the magnets.

$\cancel{F = BQ}$ $F = BIL$

$0.45 \times 9.81 = B \times 3.1 \times 40 \times 10^{-3}$

$B = 35.6\ T$

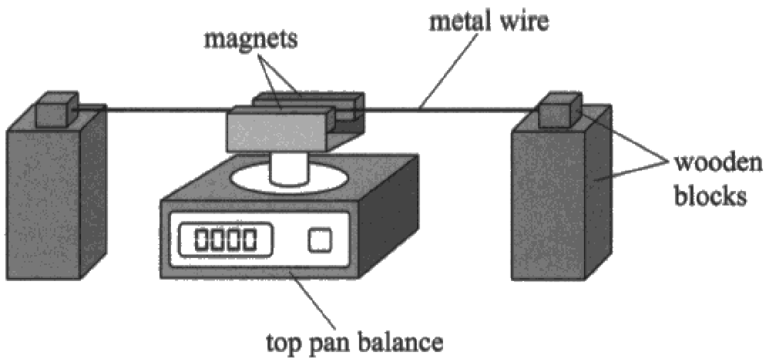
Magnetic flux density = 35.6T

ResultsPlus
Examiner Comments

This candidate scored 2 out of 3 marks.

This candidate used mass in place of force.

13 A student placed two magnets on a top pan balance. The student clamped a metal wire horizontally in the uniform magnetic field between the magnets, as shown.



The student connected the ends of the metal wire to a battery, an ammeter and a switch.

When the switch was closed, the reading on the ammeter was 3.1 A. The reading on the balance increased by 0.45 g.

The length of the metal wire in the magnetic field was 40 mm.

Calculate the magnetic flux density in the region between the magnets.

$F = BIL \sin\theta$

$\cancel{0.45 \times 10^{-3}} = B \times 3.1 \times 40 \times \cancel{10^{-3}} \times 1$

$B = \dfrac{0.45}{3.1 \times 40}$

$B = 3.63 \times 10^{-3}$ T //

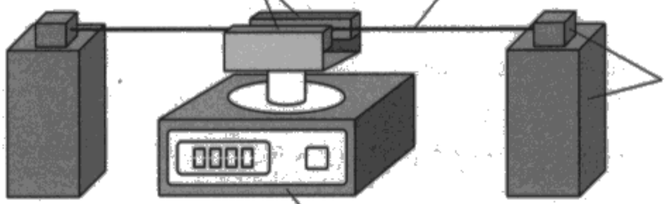
Magnetic flux density = 3.63×10^{-3} T

ResultsPlus
Examiner Comments

This candidate only scored 1 out of 3 marks.

At this level, the mark is awarded for substituting values into the equation, not just for writing down the correct equation.

13 A student placed two magnets on a top pan balance. The student clamped a metal wire horizontally in the uniform magnetic field between the magnets, as shown.



The student connected the ends of the metal wire to a battery, an ammeter and a switch.

When the switch was closed, the reading on the ammeter was 3.1 A. The reading on the balance increased by 0.45 g.

The length of the metal wire in the magnetic field was 40 mm.

Calculate the magnetic flux density in the region between the magnets.

$F = BIL\sin\theta$

$W = mg = \frac{0.45}{1000} \times 9.81 = 4.4 \times 10^{-3}\ N$

Magnetic flux density = ...

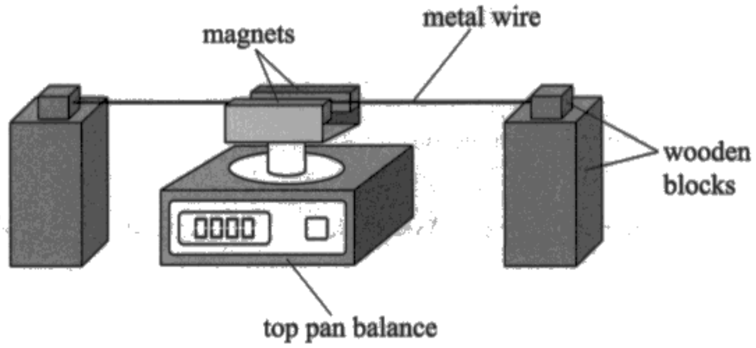
![ResultsPlus Examiner Comments]

ResultsPlus Examiner Comments

The candidate scored one mark for use of W = mg.

This candidate had used g= 10ms-2. So incurred a one mark penalty.

13 A student placed two magnets on a top pan balance. The student clamped a metal wire horizontally in the uniform magnetic field between the magnets, as shown.



The student connected the ends of the metal wire to a battery, an ammeter and a switch.

When the switch was closed, the reading on the ammeter was 3.1 A. The reading on the balance increased by 0.45 g.

The length of the metal wire in the magnetic field was 40 mm.

Calculate the magnetic flux density in the region between the magnets.

$F = BIL$ $\qquad \frac{0.45}{1000}$

$\cancel{0.4}\ 4.5 \times 10^{-3} = B \times 3.1 \times \frac{40}{1000}$

1m → 1000mm

$B = 0.03629 = 0.04$ Tesla.

Magnetic flux density = ...

![ResultsPlus Examiner Comments]

ResultsPlus Examiner Comments

This only scored 2 out of 3 marks.

ResultsPlus Examiner Tip

Always use g=9.81ms -2

Question 14(a)i

Candidates needed to say that a meson consists of one quark and one antiquark. The majority scored full marks.

14 The omega minus baryon (Ω^-) was discovered in 1964 when a negative kaon meson (K^-) was observed to collide with a stationary proton.

The Ω^- was produced in the following reaction.

$$K^- + p \rightarrow \Omega^- + K^+ + K^0$$

(a) (i) State the quark structure of a meson.

(1)

1 quark and 1 anti-quark.

ResultsPlus
Examiner Comments

A perfect answer. It is important to indicate that there is only one of each type of quark.

Question 14(a)ii

To provide a full explanation, candidates needed to identify the charge and the baryon number, as well as explain how each is conserved.

This is best achieved by writing the values in the same order as they appear in the particle equation and clearly showing how they are equal. Although this was not a "deduce" question, it is good practice in this type of question to demonstrate that both sides are equal, ideally using an equals sign.

Only about half of candidates scored full marks in this question.

(ii) Explain how the law of conservation of baryon number and the law of conservation of charge are obeyed in this reaction.

(2)

$K^- + p \rightarrow \Omega^- + K^+ + K^0$

baryon number $0 + 1 = +1 + 0 + 0$

$+1 = +1$

So baryon number conserved

charge $-1 + 1 = -1 + 1 + 0$

$0 = 0$

So charge is conserved

ResultsPlus
Examiner Comments

This is a perfect answer. The candidate clearly shows the baryon number and charge of each particle and demonstrates how conservation of each is achieved.

(ii) Explain how the law of conservation of baryon number and the law of conservation of charge are obeyed in this reaction.

(2)

The bayron nummber conservation;

Left hand side $0 + 1 \longrightarrow$ Right hand side $0 + 1 + 0$

Therefon Bayron number conserved

Charge; $-1 + 1 \longrightarrow -1 + 1 + 0$

$0 \longrightarrow 0$ ∴ Charge is conserved

ResultsPlus
Examiner Comments

This candidate scored 1 out of 2 for the charge mark but did not explain that the baryon number was conserved.

(ii) Explain how the law of conservation of baryon number and the law of conservation of charge are obeyed in this reaction.

(2)

The initial amount of baryons is 1 (due to proton), this remains as 1 since there is only one baryon after the reaction (Ω^-), hence, baryons are conserved. The overall charge before is 0 (since $-1 + 1$ is 0, due to K^- and p^+). This is the same after as the Ω^- charge of -1 cancels with K^+ $+1$ charge to remain 0 again.

ResultsPlus
Examiner Comments

This candidate scored 0. They did not identify the baryon number of every particle. They did not identify that the K 0 had no charge.

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Examiner Tip

Symbols and numbers are the best way to answer this type of question. Always write the value of the relevant quantity for each particle in the order of the particle equation, then explain that one side is equal to the other to show conservation.

Question 14(b)

This question was well answered with hardly any struggling with the conversion from kg to MeV/c2 or vice versa.

There was a range of values allowed for the answer to allow for candidates who strictly kept to the 4 significant figures given.

sides have total charge of zero. Hence baryon number and charge is conserved.

(b) Before its discovery, the mass of the Ω^- was predicted to be 2.9714×10^{-27} kg.

The most recent accepted value for the mass of the Ω^- is 1672 MeV/c^2.

Calculate the percentage difference between these two masses.

(3)

$1672\ \text{MeV}/c^2 \rightarrow m = \dfrac{1672 \times 10^6 \times 1.6 \times 10^{-19}}{(3 \times 10^8)^2} = 2.9724 \times 10^{-27}\ \text{kg}$

$\dfrac{2.9714 \times 10^{-27}}{2.9724 \times 10^{-27}} \times 100 = 99.97\ \%$

$100 - 99.97 = 0.03\%$

Percentage difference = 0.03%

ResultsPlus
Examiner Comments

This answer scored full marks - an answer at the bottom of the range using interim rounding.

(b) Before its discovery, the mass of the Ω^- was predicted to be 2.9714×10^{-27} kg.

The most recent accepted value for the mass of the Ω^- is $1672\,\text{MeV/c}^2$.

Calculate the percentage difference between these two masses.

(3)

$E = mc^2$

$= 2.9714 \times 10^{-27} \times (3.0 \times 10^8)^2$

$E = \dfrac{2.67426 \times 10^{-10}}{1.6 \times 10^{-19}}$

$E = 1.6714 \times 10^9$ eV

$E = 1671 \times 10^6$ eV

$\dfrac{1671\,\text{MeV}}{1672\,\text{MeV}} \times 100 = 99.94\%$

$100 - 99.94 = 0.06\%$

Percentage difference = 0.06 %

ResultsPlus
Examiner Comments

This answer scored full marks - an answer at the top of the range using interim rounding.

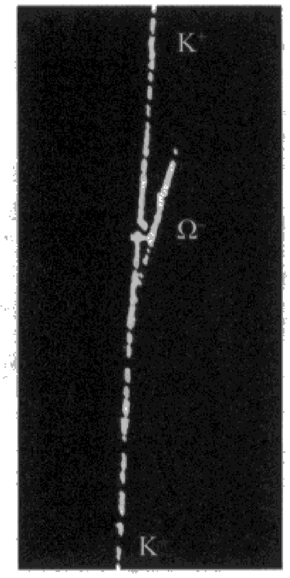
Question 14(c)

This question required candidates to explain that neutral particles do not leave tracks, in order to gain the first mark.

The remaining two marks were awarded for explaining that, to conserve momentum, one particle must travel to the left as the Ω^- moves to the right.

Most candidates scored at least one mark; however, only a minority achieved all three.

(c) The photograph shows tracks produced by particles in a particle detector when a K^- collided with a stationary proton. The tracks produced by the K^+ and Ω^- are labelled.



(Source: © Science History Images / Alamy Stock Photo)

Explain how evidence from the photograph shows that a K^0 was also formed.

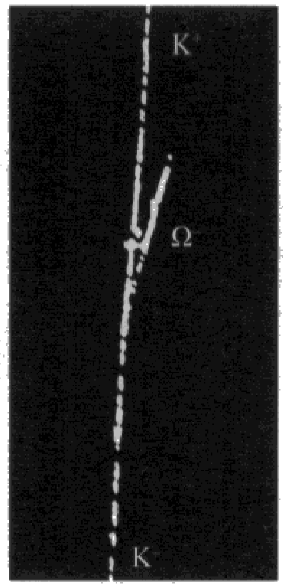
(3)

~~The~~ K^+ follows the same path as K^-. Ω^- diverts from this path towards the right. Total momentum before collision: Momentum of K^-. To conserve momentum, a particle must be produced that is diverted towards the left. No ~~path~~ is track is formed towards the left so particle must be neutral. Thus K^0 was also formed

ResultsPlus
Examiner Comments

A perfect 3 mark answer.

(c) The photograph shows tracks produced by particles in a particle detector when a K^- collided with a stationary proton. The tracks produced by the K^+ and Ω^- are labelled.



(Source: © Science History Images / Alamy Stock Photo)

Explain how evidence from the photograph shows that a K^0 was also formed.

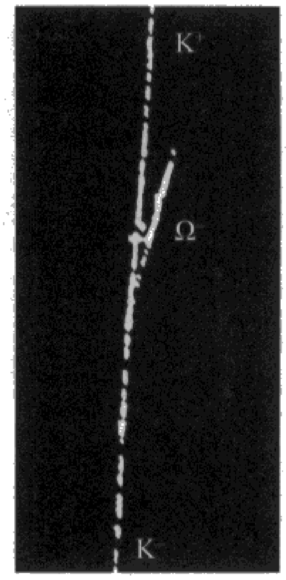
(3)

due to conservation of momentum the ~~dire~~ direction of K^+ and K^- almost same and Ω^- has a momentum perpendicular to the track of K^+ and K^-, So, there must also a perpendicular momentum ~~opposite~~ ~~at~~ ~~to~~ on the other side of the track of K^+ and K^-, and K^0 has no charge, so it will ~~no~~ not leave a ~~tra~~ track at this photograph.

ResultsPlus Examiner Comments

This response scored 2 out of 3. The final mark was not awarded because it did not clearly explain the opposite directions of the final momenta of the Ω^- and the K^0.

(c) The photograph shows tracks produced by particles in a particle detector when a K^- collided with a stationary proton. The tracks produced by the K^+ and Ω^- are labelled.



(Source: © Science History Images / Alamy Stock Photo)

Explain how evidence from the photograph shows that a K^0 was also formed.

(3)

Momentum before ~~collision~~ decay equals momentum after decay in a closed system. The K^0 cannot be seen however we can assume that it forms and is moving with the same momentum as Ω^- but ~~in the~~ towards the left with an angle almost equaling that of Ω^- from ~~it's~~ the line of movement of K^{+0} inorder to balance out the horizontal component of decay ~~before~~ after collision.

(Total for Question 14 = 9 marks)

ResultsPlus
Examiner Comments

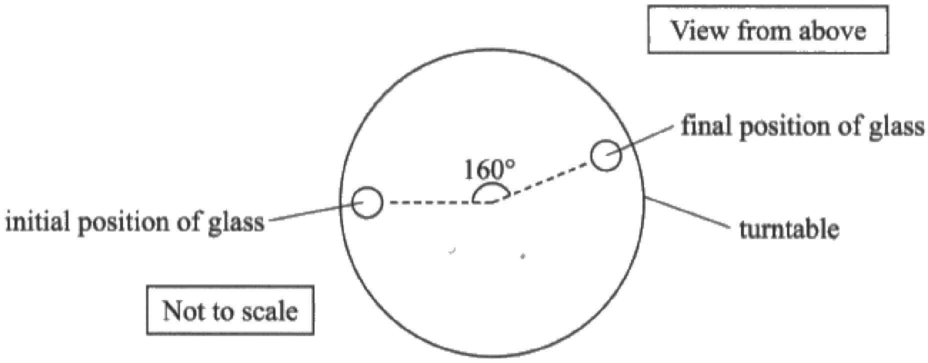
This scored 2 out of 3. It scored the two momentum marks but failed to explain that tracks of the neutral particle could not be seen. All particles can be described as unseen.

Question 15(a)i

This question was well answered by the vast majority of candidates. Most followed the first method, calculating time period then angular velocity. Those who converted from degrees to radians were more likely to make errors.

As this was a "show that" question, candidates were expected to work to one more significant figure than given in the question, and it was important to show every stage of the working to ensure all marks could be awarded.

(a) The turntable is rotated through 160°, as shown.



(i) The time taken for the turntable to be rotated through 160° is 2.2 s.

Show that the average angular velocity of the glass is about 1.3 rad s^{-1}.

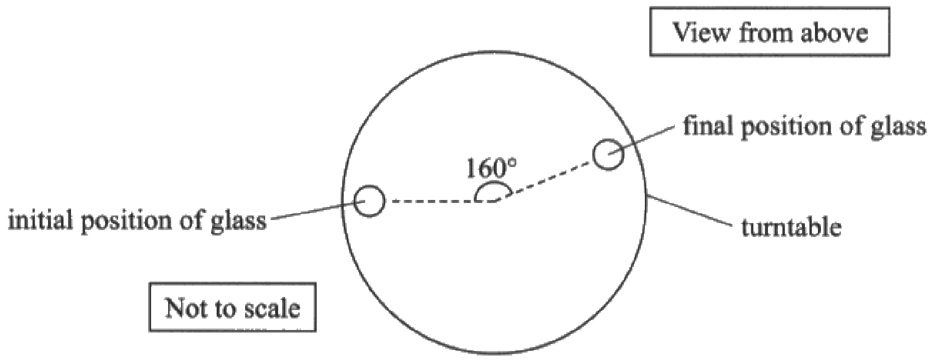
(3)

$\frac{160 \times \frac{\pi}{180}}{2.2} = \frac{40}{99}\pi = 1.26 \approx 1.3$ rad s^{-1}

ResultsPlus
Examiner Comments

This only scored 2 out of three marks, as they did not round correctly for the final mark.

(a) The turntable is rotated through 160°, as shown.



(i) The time taken for the turntable to be rotated through 160° is 2.2 s.

Show that the average angular velocity of the glass is about 1.3 rad s^{-1}.

(3)

$\frac{2\pi}{T} = W$, $\frac{72.7}{360} = 1.26$ rad s^{-1}

$\frac{160}{2.2} = 72.7°$

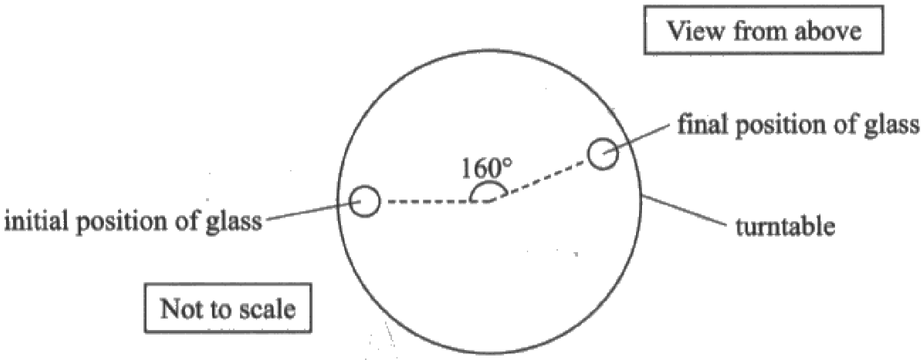
ResultsPlus Examiner Comments

This candidate scored only one mark for correctly applying the definition of ω. The mathematics on the right-hand side is incorrect, and the answer is truncated.

ResultsPlus Examiner Tip

Make sure you recognise the instruction "show that" in the command line.

(a) The turntable is rotated through 160°, as shown.



(i) The time taken for the turntable to be rotated through 160° is 2.2 s.

Show that the average angular velocity of the glass is about 1.3 rad s^{-1}.

(3)

$160 \times \frac{\pi}{180} = \frac{8}{9}\pi$ radians

$\omega = \frac{8/9\,\pi}{2.2} = 1.269 \approx 1.27$ rad s^{-1}

(about 1.3 rad s^{-1})

ResultsPlus
Examiner Comments

A perfect three-mark answer, using radians — which was the less common approach.

Question 15(a)ii

Most candidates only scored the mark for explaining the tangential velocity depends on radius and not explaining why the angular velocity was constant. Even those discussing the angular velocity often just said ‘constant because it turns through the same angle’, without mentioning time.

(ii) The glass can be placed at different positions on the turntable.

Explain why the angular velocity of the glass is the same but its velocity varies, depending on the position of the glass on the turntable.

(2)

because if radius varies velocity changes as $v=wr$ so larger radius means higher velocity. Angular velocity only depends on time taken and angle travelled therefore it is the same as it is unaffected by the radius or where you place it

ResultsPlus Examiner Comments

A perfect two mark answer.

This answer scored only the second mark. It simply repeated the information given in the question — that the angular velocity was constant — without providing further explanation.

(ii) The glass can be placed at different positions on the turntable.

Explain why the angular velocity of the glass is the same but its velocity varies, depending on the position of the glass on the turntable.

(2)

$v = wr$, as every part of the turntable are move in a same angular velocity. when the glass is near the center, r is small so velocity small when remote from center , velocity is larger.

ResultsPlus Examiner Comments

Always re-read the command line to ensure you have fully answered the question.

Question 15(b)i

This was a "deduce" question that required a numerical comparison. Since the question asked whether a distance was less than 5 cm, candidates needed to include a comparison using < or > in their answer.

The question was deliberately written in a challenging way, as the final comparison could be approached in different ways. Candidates broadly spread across the marking range. Approximately one in three achieved full marks.

(b) (i) The maximum frictional force between the glass of water and the turntable is equal to $\frac{mg}{30}$, where m is the mass of the glass of water.

Someone says that if they place the glass less than 5 cm from the edge of the turntable then the glass will slide when the turntable rotates.

Deduce whether they are correct.

angular velocity = 1.3 rad s^{-1}
diameter of turntable = 50.0 cm

(4)

$F_{friction} = \frac{mg}{30}$ $F_{centripetal} = m\omega^2 r$.

$\cancel{m}\omega^2 r = \frac{\cancel{m}g}{30}$ as friction = centripetal force.

$\omega^2 r = \frac{g}{30}$ $\rightarrow$ $r = \frac{9.81}{(1.3)^2 \times 30}$

$r = 0.19$ m. radius of table = 0.25.

$0.25 - 0.19 = 0.06$m

0.06 = max distance from edge without falling of. so student is correct.

ResultsPlus Examiner Comments

This scored 3 out of the 4 marks, it is a good answer but did not include a numerical comparison so missed the last mark. The candidate should have included 6cm>5cm.

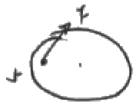
ResultsPlus Examiner Tip

Always include a numerical comparison and a conclusion in deduce questions.

(b) (i) The maximum frictional force F between the glass of water and the turntable is equal to $\frac{mg}{30}$, where m is the mass of the glass of water.

Someone says that if they place the glass less than 5 cm from the edge of the turntable then the glass will slide when the turntable rotates.

Deduce whether they are correct.



angular velocity = 1.3 rad s^{-1}
diameter of turntable = 50.0 cm

(4)

$d: r = 50 - 5 = 45\text{cm}$.

$F = mr\omega^2 = m \cdot 0.45 \cdot 1.3^2 = 0.7605m$ N.

$f = \frac{mg}{30} = 0.327m$ N.

F $0.7605m > 0.327m$

so centripetal force (towards to centre) perpendicular to motion. bigger than friction

glass will slide down. correct claim.

ResultsPlus
Examiner Comments

This candidate only scored two marks (first and the last) as they used diameter rather than radius.

(b) (i) The maximum frictional force between the glass of water and the turntable is equal to $\frac{mg}{30}$, where m is the mass of the glass of water.

Someone says that if they place the glass less than 5 cm from the edge of the turntable then the glass will slide when the turntable rotates.

Deduce whether they are correct.

angular velocity = 1.3 rad s^{-1}
diameter of turntable = 50.0 cm

(4)

$F = m\omega^2 r$, $\frac{mg}{30} = m \times 1.3^2 \times r$

$r = 0.193\ m$

$\frac{0.5}{2} - 0.193 = 0.0565\ m > 0.05\ m$

This claim is correct as less than 0.0565 m from the edge will cause glass to slide.

ResultsPlus Examiner Comments

A perfect full 4 mark answer.

Question 15(b)ii

Candidates who scored full marks usually used equations in their answer.

However, those realising that mass didn't affect the possibility of sliding were in a minority, with the majority split evenly between the full and empty glasses being likely to slide, and scoring no marks.

(ii) Two identical glasses are placed at the same distance from the edge of the turntable. One of the glasses is filled with water and the other is empty.

Explain whether either of these glasses would be more likely to slide as the turntable is rotated.

(2)

$\frac{mv^2}{r} = \frac{mg}{30}$ no, since masses get cancelled out R & have no effect, only distance will have an effect but its same so neither of the glasses would be more likely to slide as the ~~to~~ turntable is rotated

(Total for Question 15 = 11 marks)

ResultsPlus
Examiner Comments

A full 2 mark answer using equations.

ResultsPlus
Examiner Tip

Try to use equations to support and structure your explanations in physics answers.

(ii) Two identical glasses are placed at the same distance from the edge of the turntable. One of the glasses is filled with water and the other is empty.

Explain whether either of these glasses would be more likely to slide as the turntable is rotated.

(2)

According to $F=mr\omega^2$, the centripetal force of glass with water is larger as the same radius and angular velocity. So the centripetal force of glass with water ~~m~~ is more likely to larger than the maximum frictional force and this glass would be more likely to slide.

ResultsPlus
Examiner Comments

One of the majority who scored no marks, mistakenly thinking that one glass would be more likely to slide.

Question 16(a)

The majority of candidates achieved two or more marks.

Many missed the key point that they were expected to explain the role of the potential difference and how it relates to the electric field. Since the electric field is what accelerates particles in both machines, failing to mention it significantly reduced the chances of gaining marks.

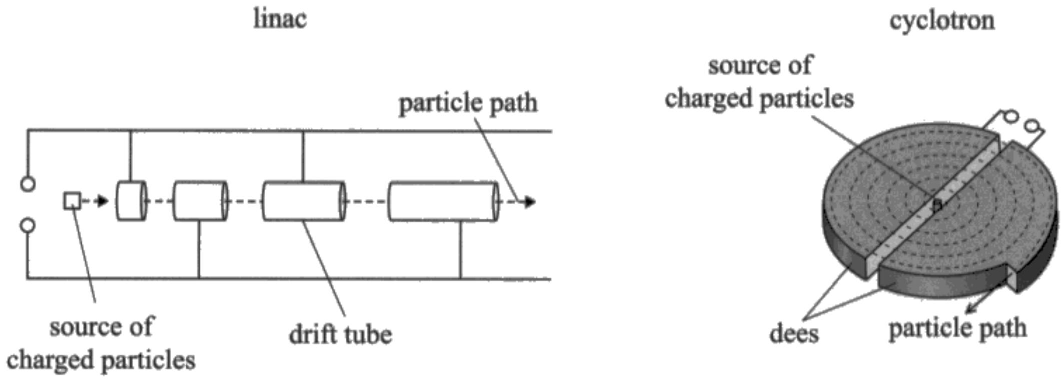
IC1, IC2, and IC4 could be credited for either machine, while IC3, IC5, and IC6 required explanations covering both the linac and the cyclotron. IC1 was rarely seen, despite being considered an 'easy' mark, whereas IC2 was usually identified. IC3 was often only partially addressed — candidates more frequently explained the linac than the cyclotron. IC4 was cited much more frequently, showing that candidates generally understand the concept of repeated acceleration.

Those who scored IC5 typically used the alternative option: constant time in tubes/Dees. There was a considerable amount of unnecessary discussion about magnetic fields, and some candidates mistakenly believed the potential difference was responsible for the magnetic field.

IC6 was answered reasonably well, although many candidates omitted reference to the cyclotron frequency.

This scored 3 marks 2 IC marks and 1 linkage mark.

16 The simplified diagrams show a linac and a cyclotron. Both machines are used to accelerate charged particles.



*(a) Explain how these machines use a potential difference to accelerate charged particles.

(6)

At linac, pontential difference gives a electric field in the gap of tube.

Electric ~~feild~~ field accelerates ~~x~~ charged particle.

The a.c ~~poten~~ potential difference change polarity to keep same direction of particle.

At cyclotron, potential difference gives a electric field to accelerate charged particle between the dees. The potential difference change polarity every ~~cycle~~ half cycle to keep particle path.

ResultsPlus
Examiner Comments

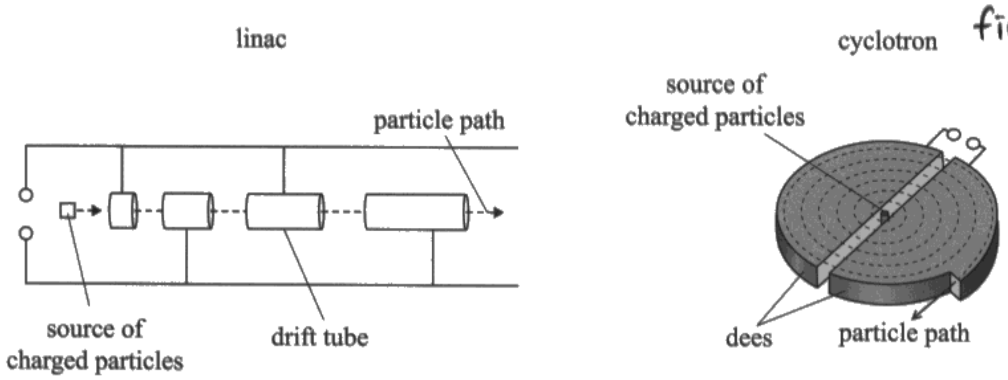
The candidate clearly explains the first two IC marks for both the Linac and the cyclotron and then explains IC 3 separately for each machine.

This is a full-mark answer: 6 marks awarded (4 IC and 2 for linkage).

The separation of some points is acceptable, provided the meaning remains clear.

W = VQ hence charged particle gain energy in ~~the~~ moving across the electric field.

16 The simplified diagrams show a linac and a cyclotron. Both machines are used to accelerate charged particles.



*(a) Explain how these machines use a potential difference to accelerate charged particles.

~~done the the~~ potential

(6)

In the linac, there is an electric field ~~between~~ ~~the~~ in the gaps between the drift tubes. The charged particles accelerate in ~~these gaps~~ this electric field and gain energy/speed. This electric field is due to the potential difference applied between two drift tubes. The alternating p.d. has a constant frequency and polarity of the p.d. changes when the charged particle is inside the drift tube. This ensures that the charged particles are always accelerated in the gaps since the next ~~to~~ drift tube will have the opposite polarity. In the cyclotron, p.d. is applied between the two 'dees' and there is an electric field in the gap between the dees. Here also the pd. has a constant frequency since the charged particle spends the same time in each dee.

In Linac the drift tubes get longer so that the charged particle spend the same time in each drift tube. In cyclotron the radius of the path increases ~~d~~ to deal with the increasing speed.

ResultsPlus
Examiner Comments

IC3 in lines 1 and 3, IC2 line 4, IC1 line 5, IC4 line 9, IC5 via constant time in Dees and tubes in unlined section at the bottom, IC6 lines 7,8 and 14,15.

Question 16(b)

This was a "show that" question followed by a "deduce" question. Around half of the candidates managed to score full marks on both parts.

In part (a), some candidates missed the factor of 4 in their calculation, although the "show that" format helped prompt a few towards the correct answer. As expected in this type of question, at least one extra significant figure was required to gain full marks.

In part (b), being a "deduce" question, candidates were expected to provide a quantitative (numerical) comparison along with a clear conclusion.

(b) A scientist plans to use each type of particle accelerator to accelerate protons from rest.

(i) In the linac, a potential difference of 0.40 MV is applied to the tubes. The protons pass through 4 gaps.

Show that the speed of the protons is about $2 \times 10^7\,m\,s^{-1}$ as they leave the 4th gap.

(4)

0.4MV $E_p = QV = 1.6 \times 10^{-19} \times 10^{6} \times 0.4 = 6.4 \times 10^{-14}$

$KE = 4E_p$ $\frac{1.67 \times 10^{-27} V^2}{2} = 2.56 \times 10^{-13}$

$V^2 = 3.066 \times 10^{14}$

$V \approx 1.75 \times 10^{7}\,m/s$

(ii) In the cyclotron, the protons leave the dees when the radius of their path is 29 cm.

Deduce whether the speed of the protons as they leave the cyclotron is the same as the speed of the protons as they leave the 4th gap in the linac.

magnetic flux density = 0.55 T

(3)

$F = \frac{mv^2}{r} = \frac{m_p V^2}{0.29m} = BQ_eV$ 0.29m

$\frac{m_p V}{0.29} = 0.55e$

~~Not the same~~

$V = \frac{2.552 \times 10^{-20}}{1.67 \times 10^{-27}} = 1.53 \times 10^{7}\,m/s$

$1.53 \times 10^7 < 1.75 \times 10^7$

~~but similar~~ yes, the same,

within range of experimental accuracy.

ResultsPlus
Examiner Comments

This candidate scored 4 and 2 marks, losing the final mark because the explanation did not match the quantitative (numerical) comparison.

(b) A scientist plans to use each type of particle accelerator to accelerate protons from rest.

(i) In the linac, a potential difference of 0.40 MV is applied to the tubes. The protons pass through 4 gaps.

Show that the speed of the protons is about $2 \times 10^7\,\mathrm{m\,s^{-1}}$ as they leave the 4th gap.

(4)

$W = QV$, W gained from each gap $= (1.6 \times 10^{-19})(0.4 \times 10^6)$

$= \cancel{6.4 \times 10^{-16}\,J}\ 6.4 \times 10^{-14}$

total W gained $= 4 \times 6.4 \times 10^{-14} = 2.56 \times 10^{-13}$

$E_k = \frac{1}{2}mv^2$, $v = \sqrt{\frac{2E_k}{m}} = \sqrt{\frac{2(2.56 \times 10^{-13})}{1.67 \times 10^{-27}}}$

$v = 1.75 \times 10^7\ \mathrm{ms^{-1}}$

(ii) In the cyclotron, the protons leave the dees when the radius of their path is 29 cm.

Deduce whether the speed of the protons as they leave the cyclotron is the same as the speed of the protons as they leave the 4th gap in the linac.

magnetic flux density = 0.55 T

(3)

$\cancel{F =}\ r = \frac{p}{Bq}$, $p = mv$, $r = \frac{mv}{Bq}$, $v = \frac{rBq}{m}$

$v = \frac{(29 \times 10^{-2})(0.55)(1.6 \times 10^{-19})}{1.67 \times 10^{-27}} = 1.53 \times 10^7\ \mathrm{ms^{-1}}$

ResultsPlus Examiner Comments

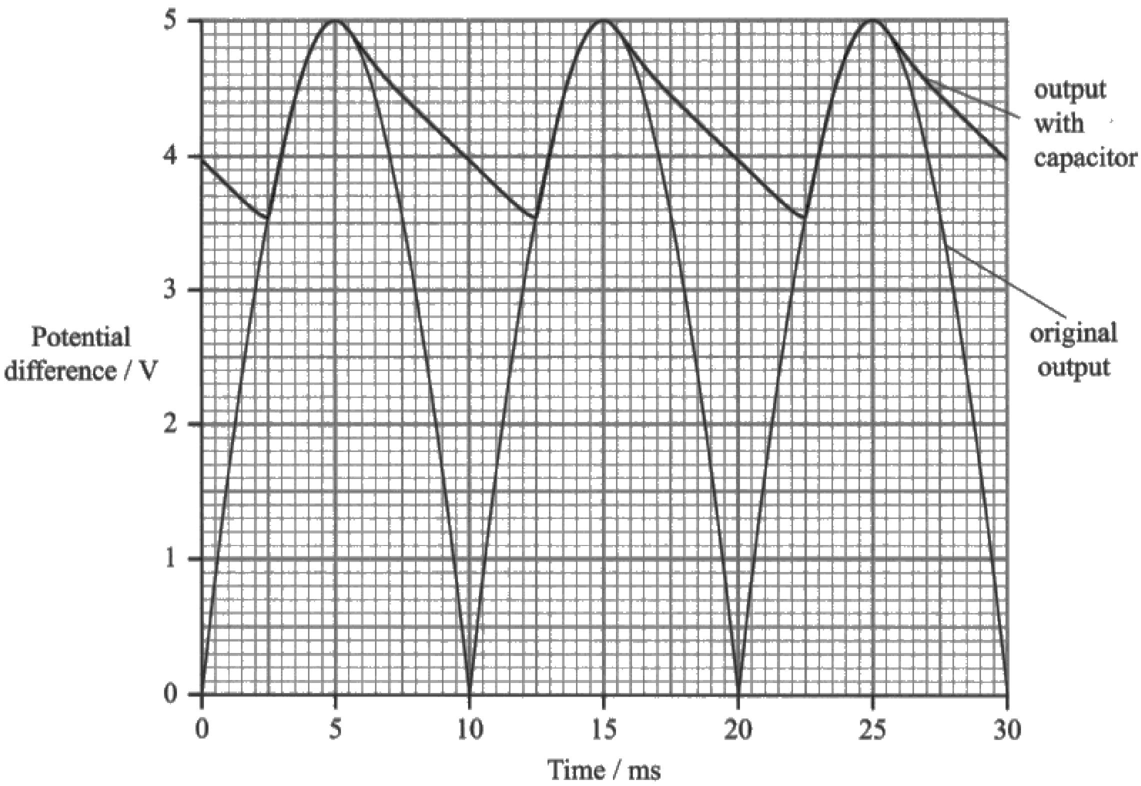
This candidate lost the final mark in the second part by failing to compare the two speeds.

Question 17(a)

Candidates were required to read a value from a graph for this question, and the majority succeeded in gaining the mark. Unfortunately, some failed to include the correct unit and therefore did not score.

A capacitor can be connected to the power supply to modify this output.

As the output increases, the capacitor charges. The capacitor modifies the output and produces the variation shown by the bold line on the graph below.



(a) State the potential difference across the capacitor at the end of a period of discharge.

(1)

Potential difference = 3.55

ResultsPlus Examiner Comments

This candidate read the graph correctly but failed to include a unit.

ResultsPlus Examiner Tip

Always give your answer with units.

Question 17(b)i

There was a wide range of marks awarded for this question, with approximately one third of candidates achieving full marks.

There was a strong hint to use the bold line on the graph, and candidates were expected to recognise discharging section of the curve. The only effective method was to take values directly from the graph and substitute them into the relevant equation — a method that the majority of candidates successfully employed.

(b) The capacitor discharges through a resistor labelled with a value of 6.8 kΩ and a tolerance of ± 5%.

The capacitor has a capacitance of 3.3 μF.

(i) Deduce whether the output with the capacitor shown on the graph is consistent with a resistor tolerance of ± 5%.

$V = 3.5 \quad V_0 = 5$

(5)

$V = V_0 \cdot e^{-\frac{t}{RC}}$ One complete discharge period = 7.5ms

$\ln V = \ln V_0 - \frac{t}{RC}$

$\frac{t}{RC} = \ln V_0 - \ln V$

$\frac{1}{R} = \frac{C}{t}(\ln V_0 - \ln V)$

$\frac{1}{R} = \frac{3.3\times10^{-6}}{7.5\times10^{-3}}(\ln 5 - \ln 3.5)$

$\frac{1}{R} = \cancel{1.57\times10^{-4}}\ 1.51\times10^{-4}$

$R = \cancel{6372\ \Omega}\ 6636\ \Omega$

~~$1-(6372 \div 6.8\times10^3)\times100\% = 6.29\%$~~

~~no, it's 6.29% less than 6.8kΩ exceeded ±5% tolerance~~

$1-(6636 \div 6.8\times10^3)\times100\% = 2.41\%$

yes, it is within ±5% tolerance

ResultsPlus
Examiner Comments

This was a nicely explained and clear 5 mark answer. This candidate made a slightly more complex answer in terms of the 5% than needed, but explained it well.

(b) The capacitor discharges through a resistor labelled with a value of 6.8 kΩ and a tolerance of ± 5%.

The capacitor has a capacitance of 3.3 μF.

(i) Deduce whether the output with the capacitor shown on the graph is consistent with a resistor tolerance of ± 5%.

(5)

$3.52 = 5 \cdot e^{-\frac{7.5\times10^{-3}}{6800C}}$

$C = \frac{-7.5\times10^{-3}}{6800/\ln\frac{3.52}{5}} = 3.14\times10^{-6}F$

$= 3.14\,\mu F$

$3.3\times0.95 = 3.135 < 3.14$

consistent

ResultsPlus
Examiner Comments

This candidate correctly interpreted the graphical points but mistakenly assumed that the tolerance applied to the capacitance rather than the resistance. As a result, they did not achieve either the correct answer mark or the correct comparison mark.

Question 17(b)ii

This question required the use of a straightforward formula and a difference in potential difference. Around half of the candidates scored full marks. Many lost marks due to mathematical errors, particularly by finding the difference in potential differences and then incorrectly squaring it.

(ii) Calculate the change in the energy stored in the capacitor during the discharging process.

(3)

$W = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$.

$\Delta V = 5 - 3.5 = 1.5V$

$W = CV^2 \times 0.5 = 3.3 \times 10^{-6} \times 1.5^2 \times 0.5$

$= 3.71 \times 10^{-6}$

Change in the energy stored = 3.71×10^{-6}

ResultsPlus
Examiner Comments

This response scored only one mark because the candidate did not correctly use the difference in potential difference.

(ii) Calculate the change in the energy stored in the capacitor during the discharging process.

(3)

$E = \frac{1}{2}QV$

$E = \frac{1}{2}CV^2 = \frac{1}{2} \times 3.3\times10^{-6} \times (5^2 - 3.5^2) = 2.10\times10^{-5}$ J

Change in the energy stored = 2.10×10^{-5} J.

ResultsPlus
Examiner Comments

This response scored full marks.

Question 17(b)iii

This was a challenging question, but the majority of candidates gained some marks by correctly explaining that the time constant decreased, resulting in the capacitor discharging more quickly. However, many missed the third mark by simply repeating information given in the question.

(iii) The resistor is replaced by a bulb with a much lower resistance than 6.8 kΩ.

Explain why the output is now very similar to the original output of the power supply.

(3)

Resistance smaller, $\tau = RC$, time constant decrease, the voltage decrease with higher rate, the gradient of graph became more negative, the final minimum voltage at the end of dischage process decrease, more similar to original output graph.

ResultsPlus Examiner Comments

The candidate scored the first two marks and made an attempt at the final mark. However, to gain this mark, they needed to explain that the capacitor could fully discharge before the next charging cycle began.

(iii) The resistor is replaced by a bulb with a much lower resistance than 6.8 kΩ.

Explain why the output is now very similar to the original output of the power supply.

(3)

Since the resistor is way more smaller, the time constant $\tau = RC$ is way more smaller. Hence, it takes much less time to both charge and discharge. And therefore, V drops to nearly 0 in one period that the output is very similar to the original one.

ResultsPlus Examiner Comments

This candidate just managed to achieve the final mark, securing all three marks overall.

Question 18(a)

This question was generally well answered, with the vast majority of candidates scoring at least one mark, and a significant minority achieving full marks.

Almost all candidates gained the fourth mark by stating that an emf is induced. Most also achieved the first mark by correctly explaining that the current produces a magnetic field. The most challenging mark to obtain was the third, which required candidates to explain that the coil in the mobile phone caused a change in flux linkage or cut lines of magnetic flux.

(a) Explain how the mobile phone charges when placed near to the charger.

(4)

~~As~~ The a.c. current produces a magnetic field. As current is alternating, magnetic field is alternating. When phone is near to charger There's a change in ~~magn~~ flux linkage with ~~of~~ second coil. An e.m.f. is induced across second coil. As the coil is conductor, there's a complete closed circuit. ~~An induce~~ A current is induced in the mobile phone coil. Mobile phone charges.

ResultsPlus
Examiner Comments

This was a perfect response, clearly addressing all four marking points.

(a) Explain how the mobile phone charges when placed near to the charger.

(4)

There is AC current in the charger coil. This produces a magnetic field ~~of~~ that changes direction. The coil in the mobile phone cut through the magnetic flux emf is induced. So there is a current in coil. This coil is connect to the ~~ch~~ battery of the mobile phone. Which charges the phones.

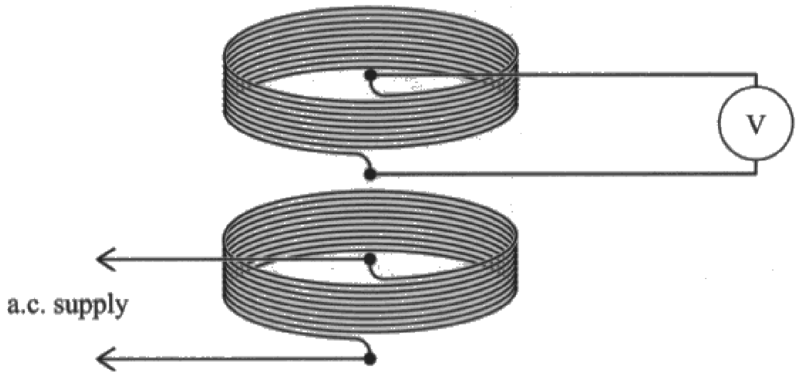
ResultsPlus
Examiner Comments

This candidate scored three marks, just missing the third marking point by omitting the word " lines " at the end of the third row.

Question 18(b)i

This question was well answered, with the majority of candidates gaining full marks. The most common error was the use of an incorrect unit.

(b) A teacher demonstrated a simplified version of the charger to her class. She used two identical coils. She attached one coil to an a.c. supply and the other coil to a digital voltmeter.



The magnetic flux density produced by the coil connected to the a.c. supply has a maximum value of 18 mT.

(i) Calculate the maximum magnetic flux linkage for the coil connected to the a.c. supply.

diameter of coils = 4.0 cm

number of turns in each coil = 50

(4)

$A = \left(\frac{4\times10^{-2}}{2}\right)^2 \pi = 1.26\times10^{-3}\ m^2$

$\Phi = B \cdot A \cdot N$

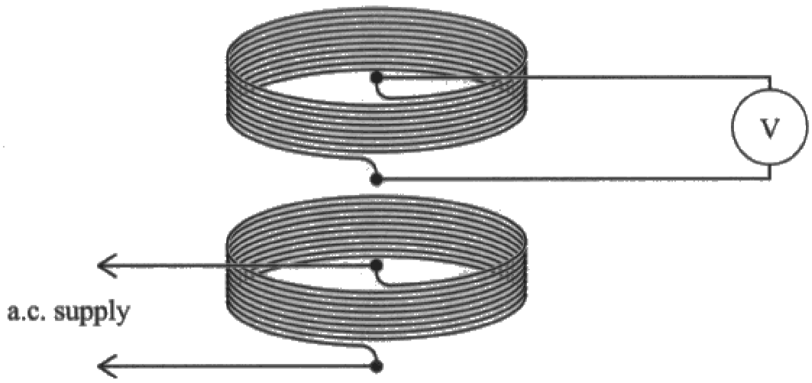
$= 18\times10^{-3} \times 1.26\times10^{-3} \times 50 = 1.13\times10^{-3}\ Wb$

Maximum magnetic flux linkage = 1.13×10^{-3} Wb ~~1.11 × 10^-6 Wb~~

ResultsPlus
Examiner Comments

This response scored full marks.

(b) A teacher demonstrated a simplified version of the charger to her class. She used two identical coils. She attached one coil to an a.c. supply and the other coil to a digital voltmeter.



The magnetic flux density produced by the coil connected to the a.c. supply has a maximum value of 18 mT.

(i) Calculate the maximum magnetic flux linkage for the coil connected to the a.c. supply.

diameter of coils = 4.0 cm
number of turns in each coil = 50

(4)

$B = 18 \times 10^{-3}$ $\quad N = 50$

$A = \pi \times (2 \times 10^{-2})^2 \times 50$

$\Phi = BA$ $\quad = 0.0628\ m^2$

$\Phi = 18 \times 10^{-3} \times 0.0628$

$= 1.13 \times 10^{-3}\ Tm^{-1}$

Maximum magnetic flux linkage = $1.13 \times 10^{-3}\ Tm^{-1}$

ResultsPlus
Examiner Comments

This response lost a mark for having the wrong unit.

Question 18(b)ii

This was a challenging question, and few candidates were able to achieve the mark. To gain credit, candidates needed to explain that the flux linked by the coil connected to the a.c. supply was not fully linked with the coil connected to the voltmeter. However, many responses focused incorrectly on energy dissipation or resistance instead.

(ii) The maximum potential difference across the coil connected to the digital voltmeter is less than the maximum potential difference of the a.c. supply.

Suggest why.

(1)

Energy is lost to surroundings

ResultsPlus
Examiner Comments

This response achieved no marks.

(ii) The maximum potential difference across the coil connected to the digital voltmeter is less than the maximum potential difference of the a.c. supply.

Suggest why.

(1)

There is distance between the two coils so the strength of magnetic ~~[illegible]~~ flux linkage in the coil with voltmeter is also lower, hence the change in magnetic flux linkage with the coil with voltmeter is also lower.

(Total for Question 18 = 9 marks)

ResultsPlus
Examiner Comments

A well-explained response that successfully gained the mark.

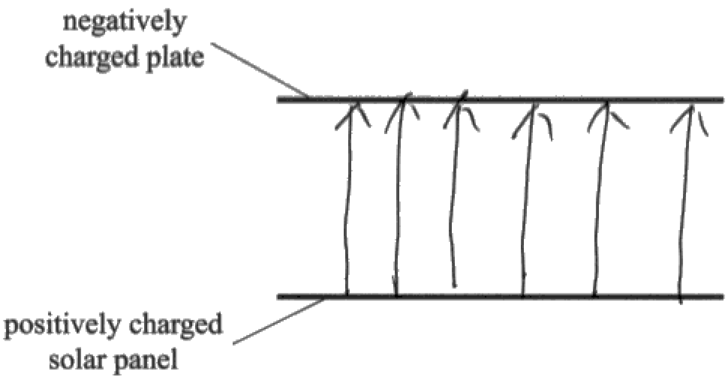
Question 19(a)

At the front of every paper, the required equipment is listed. A scientific calculator is always needed, and sometimes a ruler is required. For this paper, a ruler was needed, specifically for the question shown here.

19 In desert areas of California, solar panels use sunlight to generate electrical power. If sand collects on the solar panels, their efficiency is reduced.

To remove sand, a positive electric charge is given to the sand particles and a negatively charged plate is moved across the panel.

(a) The diagram shows a negatively charged plate above a positively charged solar panel.



Add to the diagram to show the electric field lines between the plate and the solar panel.

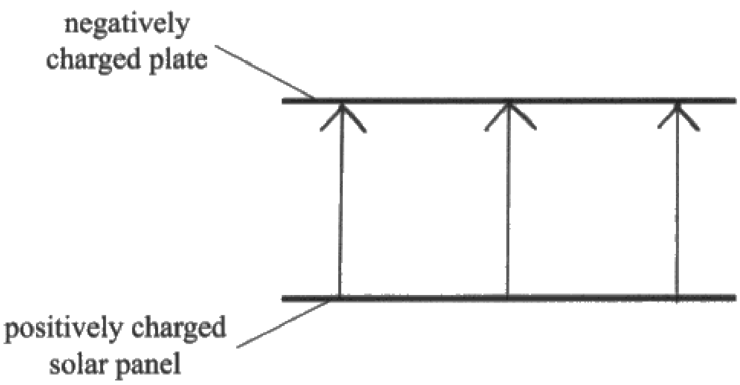
ResultsPlus
Examiner Comments

This candidate’s lines were not evenly spaced, vertical, or touching the wires, so they only scored the first mark for the arrows. The candidate would have benefited from using a ruler.

19 In desert areas of California, solar panels use sunlight to generate electrical power. If sand collects on the solar panels, their efficiency is reduced.

To remove sand, a positive electric charge is given to the sand particles and a negatively charged plate is moved across the panel.

(a) The diagram shows a negatively charged plate above a positively charged solar panel.



Add to the diagram to show the electric field lines between the plate and the solar panel.

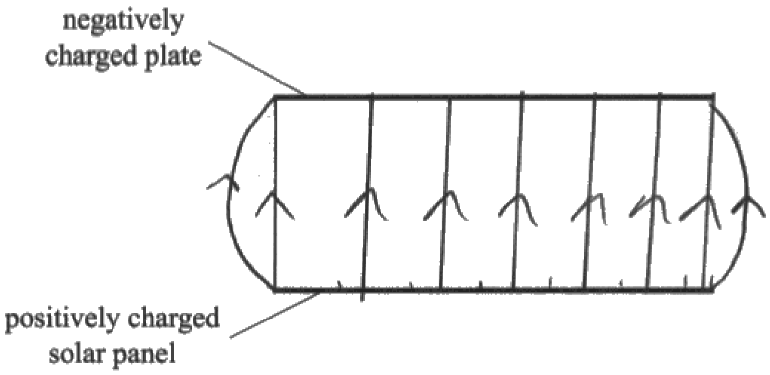
ResultsPlus
Examiner Comments

A perfect two-mark answer; note that the candidate has not drawn more lines than necessary.

19 In desert areas of California, solar panels use sunlight to generate electrical power.
If sand collects on the solar panels, their efficiency is reduced.

To remove sand, a positive electric charge is given to the sand particles and a negatively charged plate is moved across the panel.

(a) The diagram shows a negatively charged plate above a positively charged solar panel.



Add to the diagram to show the electric field lines between the plate and the solar panel.

ResultsPlus Examiner Comments

This candidate drew more than the required three lines, which likely wasted time and may have cost a mark, as it is much harder to make extra lines evenly spaced. Please note that edge effects are not required and are always ignored when marking.

ResultsPlus Examiner Tip

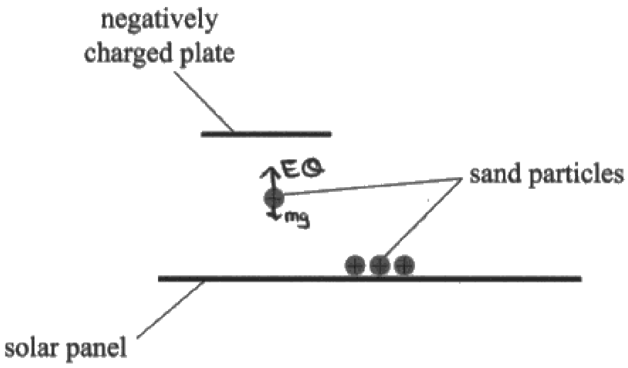
Use a ruler to draw field lines, and avoid drawing more than necessary.

Question 19(b)i

This question was taken directly from the specification requirement to "_*understand that an electric field is defined as a region where a charged particle experiences a force.*"_ Few candidates achieved full marks, with the majority failing to score at all.

(b) A positive electric charge is given to the sand particles when the solar panel is charged.
When the negatively charged plate is moved across the solar panel, the sand particles move off the panel, as shown below.

$E = \frac{F}{Q}$



(i) Explain why a sand particle moves as shown.

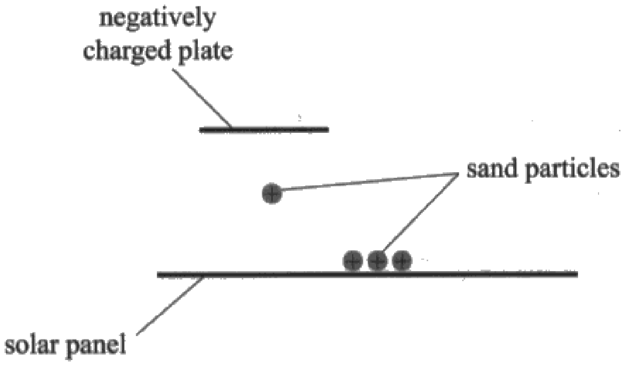
(2)

The sand particle has a resultant force upwards
$F_R = EQ - mg$ so it accelerate up

ResultsPlus
Examiner Comments

This achieved the second mark, but could have achieved the first mark if they had explained the terms in their equation.

(b) A positive electric charge is given to the sand particles when the solar panel is charged.
When the negatively charged plate is moved across the solar panel, the sand particles move off the panel, as shown below.



(i) Explain why a sand particle moves as shown.

(2)

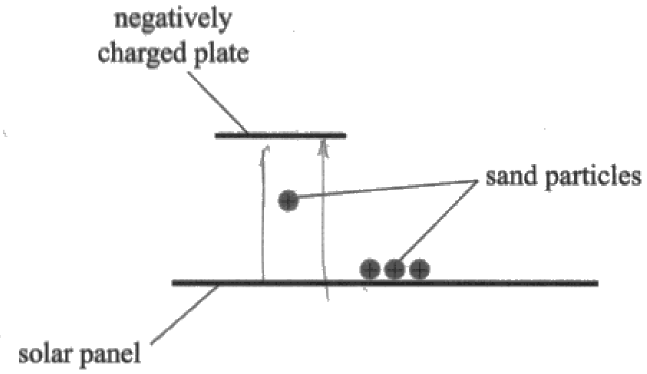
Because the sand particles acted a ~~force~~ ~~a~~ upward force from the electric filed. When the value of electric force is larger than the weight of sand particles, the particles move of the panel.

![ResultsPlus Examiner Comments]

ResultsPlus Examiner Comments

This response only achieved the second mark. The first mark was not awarded because the candidate failed to mention that the particle was charged.

(b) A positive electric charge is given to the sand particles when the solar panel is charged.
When the negatively charged plate is moved across the solar panel, the sand particles move off the panel, as shown below.



(i) Explain why a sand particle moves as shown.

(2)

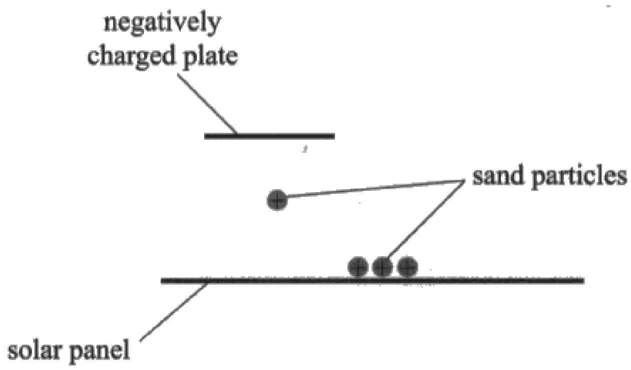
The negatively charged plate and the sand particles have opposite charge. Opposite charges attract each other. Also, the sand particle and the solar panel has the same charge and sand particles is repelled from it.

ResultsPlus
Examiner Comments

This candidate was typical of many who failed to score, as they did not appreciate that this is an electric field and that movement is caused by the forces within the field.

This candidate scored two marks by using the alternative phrasing, "the charged particle experiences electrostatic force," and by explaining that this force was greater than the weight.

(b) A positive electric charge is given to the sand particles when the solar panel is charged.
When the negatively charged plate is moved across the solar panel, the sand particles move off the panel, as shown below.



(i) Explain why a sand particle moves as shown.

(2)

The negatively charged plate attracts positively charged sand and the electrostatic force is upward and larger than weight.

![ResultsPlus Examiner Comments]

ResultsPlus
Examiner Comments

This candidate scored two marks by using the alternative phrasing, "the charged particle experiences electrostatic force," and by explaining that this force was greater than the weight.

Question 19(b)ii-iii

This question was well answered, with the vast majority scoring full marks on the first part and around half of the candidates achieving full marks on the second part.

In Biii, most candidates correctly calculated the force. Many attempted to use Coulomb's law to find a radius, which then allowed them to score the marks for volume and, in some cases, weight and density. The most common error was forgetting that they had calculated a radius rather than a diameter, leading them to incorrectly select the 310 μm particle.

(ii) Show that the electric field strength between the negatively charged plate and the solar panel is about $8.1 \times 10^5 \mathrm{V\,m^{-1}}$.

distance between plate and solar panel = 1.50 cm
potential difference between plate and solar panel = 12.2 kV

(2)

$E = \frac{V}{d}$ $\frac{12{,}2 \times 10^3}{1{,}5 \times 10^{-2}} = E$

$E = 8{,}1 \times 10^5\ \mathrm{Vm^{-1}}$

(iii) The maximum positive charge that can be given to the sand particles when the solar panel is charged is 4.0×10^{-12} C.

The table below shows the diameters of some sand particles.

Diameter of sand particle / µm	310	590	720	970

Only some of these particles could be lifted from the solar panel when using an electric field strength of $8.1 \times 10^5 \mathrm{V\,m^{-1}}$.

Deduce the largest diameter of sand particles given in this table that could be lifted from the solar panel.

density of sand = $2600 \mathrm{kg\,m^{-3}}$

(6)

$ma = qE - mg = \Sigma F$ $qE = 4 \times 10^{-12} \times 8{,}1 \times 10^5$

$mg = qE$ $qE = 3{,}24 \times 10^{-6}$ N

$9{,}81 \times \rho V = qE$

$\frac{3{,}24 \times 10^{-6}}{(9{,}81 \times 2600)} = V$ $V = 1{,}2703 \times 10^{-10}\ \mathrm{m^3}$

$V = \frac{4}{3}\pi r^3$

$\sqrt[3]{\frac{1{,}2703 \times 10^{-10} \times 3}{4\pi}} = r$

$r = 3{,}118 \times 10^{-4}$ m diameter $= r \times 2$ $\approx 622\ \mu$m

$r = 311\ \mu$m the largest diameter is 590 µm

ResultsPlus
Examiner Comments

This is a full mark answer.

(ii) Show that the electric field strength between the negatively charged plate and the solar panel is about $8.1 \times 10^5 \text{V m}^{-1}$.

distance between plate and solar panel = 1.50 cm
potential difference between plate and solar panel = 12.2 kV

(2)

$E = \frac{V}{d} = \frac{12.2 \times 10^3}{1.50 \times 10^{-2}} = 8.13 \times 10^5 \text{ Vm}^{-1}$

(iii) The maximum positive charge that can be given to the sand particles when the solar panel is charged is 4.0×10^{-12} C.

The table below shows the diameters of some sand particles.

Diameter of sand particle / μm	310	590	720	970

Only some of these particles could be lifted from the solar panel when using an electric field strength of $8.1 \times 10^5 \text{V m}^{-1}$.

Deduce the largest diameter of sand particles given in this table that could be lifted from the solar panel.

density of sand = 2600kg m^{-3}

(6)

$E = \frac{F}{Q}$

$(8.1 \times 10^5)(4.0 \times 10^{-12}) = 3.24 \times 10^{-6}$ N

$E = \frac{kQ}{r^2} = \frac{(8.99 \times 10^9)(4.0 \times 10^{-12})}{r^2} = 8.1 \times 10^5$ E

$r^2 = \frac{(8.99 \times 10^9) \times (4.0 \times 10^{-18})}{(8.1 \times 10^5)} = 4.44 \times 10^{-8}$

$r = \sqrt{4.44 \times 10^{-8}} = 211 \times 10^{-6} \times 2 =$

$d = 422$ um

422 um is the largest.

~~f=~~ $V = \frac{4}{3}\pi(211 \times 10^{-6})^3$

$V = 3.93 \times 10^{-11}$

$\rho = \frac{M}{V}$

~~m = 1.~~ kg.

$M = 1.0 \times 10^{-7}$ kg

ResultsPlus
Examiner Comments

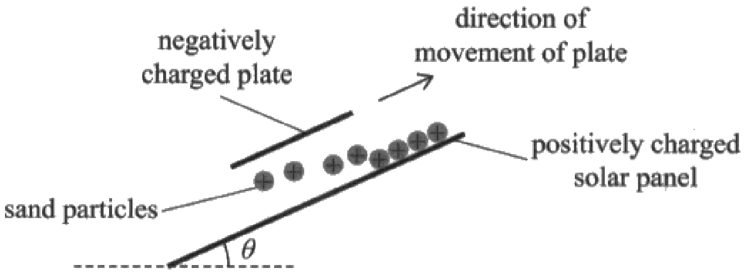
This candidate scored full marks for the first part and three marks for the second. The first mark is shown in the left-hand corner, with the volume in the right-hand corner and the density written underneath. Unfortunately, the candidate applied Coulomb's law, which is irrelevant here since this question does not involve point charges. They could have easily gained an additional mark by selecting the smaller particle diameter of 720 μm.

Question 19(c)

The first part of this question required candidates to add force arrows to the diagram, a common question type. Unfortunately, a large number of candidates failed to label their forces, and some drew them in incorrect directions.

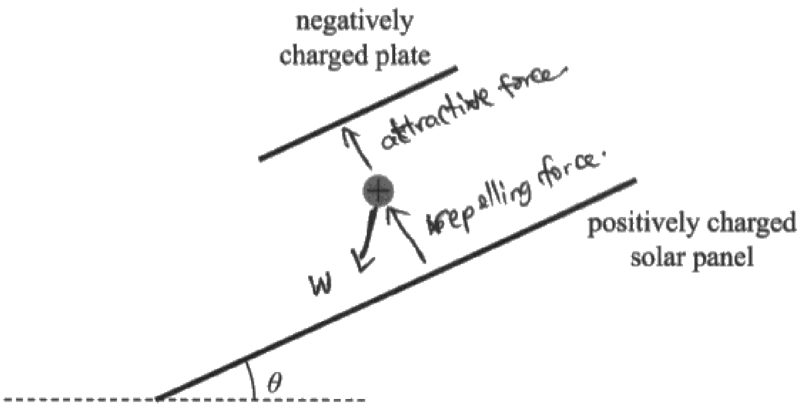
The final section was designed to be challenging, so it was encouraging that many candidates explained that the incline meant only a component of the weight needed to be lifted. However, the last mark depended on the first being achieved, requiring candidates to explain that the benefit of the incline was that more massive particles could be lifted. Only a small minority of candidates achieved this.

(c) The solar panels are usually inclined at an angle θ to the horizontal. The plate moves parallel to the solar panel, as shown.



(i) Add to the diagram below to show the forces acting on a charged sand particle.

(2)



(ii) Explain how inclining the solar panel at an angle θ would improve the removal of sand particles from the solar panel.

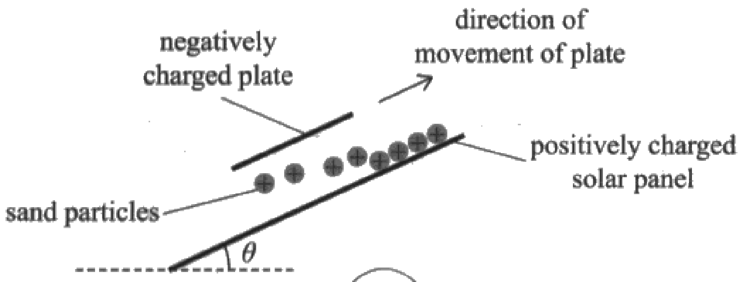
(2)

The sand particles will fall back due to the inclination of the solar panel as it is hard for them to move forward. The sand particle is attracted more faster to the negatively charged plate.

ResultsPlus
Examiner Comments

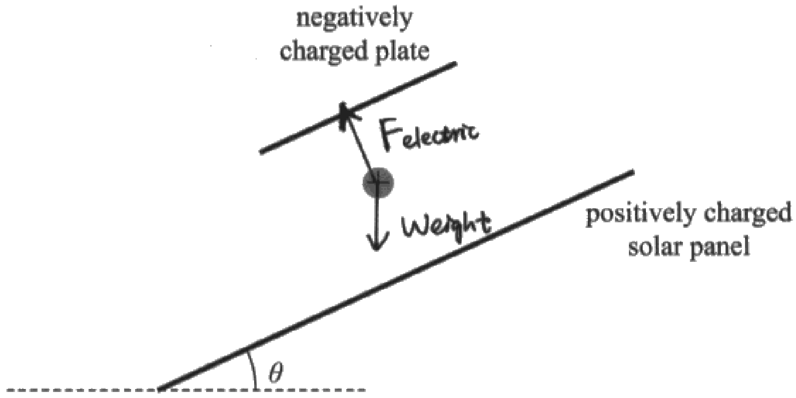
This response scored no marks in either section. The weight was not shown as acting vertically downwards, and the addition of an extra force meant that even if the weight had been correctly represented, the mark would still have been lost. Furthermore, the candidate made no reference to the benefits of the incline, such as the presence of a component of weight acting down the slope.

(c) The solar panels are usually inclined at an angle θ to the horizontal. The plate moves parallel to the solar panel, as shown.



(i) Add to the diagram below to show the forces acting on a charged sand particle.

(2)



(ii) Explain how inclining the solar panel at an angle θ would improve the removal of sand particles from the solar panel.

(2)

① the against force with electric force ~~[illegible]~~ is smaller.
as the component of weight that perpendicular to the panel is to ~~balance~~ against the force (electric)
② acceleration of particles is larger, higher efficiency.
resultant force perpendicular to plate is larger
and more massive sands can be removed. too.

ResultsPlus
Examiner Comments

A perfect answer: the labels in the first part were accurate, and the second part was clearly explained.

ResultsPlus
Examiner Tip

When drawing forces on a diagram, ensure you label them clearly and draw them in the correct direction.

Paper Summary

Based on their performance on this paper, candidates should:

- Remember when you are asked to deduce whether a statement is true using numerical evidence, that you must make a direct comparison of two values and state your conclusion in words.
- 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. "Show that" means the steps must be shown and the answer given to a greater number of significant figures than that shown in the mark scheme.
- Write numbers carefully as they appear on your calculator (correctly rounded if needed).
- In questions with mixed quantities, be sure to convert all values to standard SI base units or derived units, eg convert mm to m, g to kg, MeV to eV etc.
- Remember that physical quantities have a magnitude and a unit and both must be given in answers to numerical questions.
- While physics formulae are provided in the exam, the formulae for the circumference and radius of a circle and area and volume of a sphere must be remembered.

Grade boundaries

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