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Examiners' Report
June 2014

IAL Physics WPH04 01

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Introduction

Candidates were able to attempt all of the questions and demonstrate some understanding of the physics that was being assessed. A reasonable number of candidates scored marks for each question part with full marks being awarded to some candidates. There was no evidence that candidates did not have enough time as nearly all candidates attempted the whole paper. The table shows the percentage of correct answers for the multiple choice questions with the most common wrong answers.

Question	**Topic**	**% correct**	**Common wrong answer**
1	Atomic structure	97	-
2	Angular and linear velocity	62	B/C
3	Units magnetic flux density	64	D
4	KE particles in Linac	77	C
5	Charging current of a capacitor	82	C
6	eV to KE conversion	79	A/B
7	Units of electric field strength	68	C
8	Interpretation of a flux linkage against time graph	55	A
9	Interpretation of a force time graph to find velocity	46	D
10	Conversion of particle physics units.	65	A

Question 8 required candidates to think about the variable that was plotted and how that affected the induced e.m.f. Since the flux linkage increased at a constant rate and then had a constant value, the e.m.f. would be constant and then zero, whereas the common answer was to just describe the change in flux linkage.

In question 9 candidates did not take account of the fact that the force was decreasing over the time of launch and found the speed reached if the force had been constant at 8 N for 5 s.

Question 11

This is a familiar topic area which has been examined in the past and there is a tendency for candidates to answer the question that has been set in previous examinations rather than what has actually been asked. This question was directed to the nucleus rather than the atom as a whole. There was an expectation that candidates would say that the nucleus was very much smaller than the atom. However very few candidates did this, instead giving the answer that 'most of the atom is empty space'. The decision was made, when looking at the paper as a whole, to allow this as an alternative to 'the nucleus being very small'. This might not happen in future exam series and so it is important to encourage candidates to read the question and address what has been asked. Despite making that decision, and bearing in mind this is really factual recall, only 24% of candidates scored full marks.

Candidates obviously have a good idea of what is wanted but often lose marks through a lack of precision in their answers. The first marking point is that most of the particles go through undeflected. Examiners often saw 'with little or no deflection' or 'some go straight through'. Both of these comments are wrong. We do not credit free space in the atom. Some candidates seem to completely forget that the atom has electrons with a charge and some, albeit small, mass. So comments such as, 'all of the charge' or 'all of the mass is in the nucleus' are wrong. When Rutherford carried out his experiment, it was at a time when a lot of work was being done on atomic structure and charges, and Rutherford's experiment only proved that the nucleus was charged. His own paper says that the same results would have been obtained by either a positively or a negatively charged nucleus. It was only with later knowledge from other scientists that it was accepted that the nucleus was positive. The correct statement that candidates should make is that the nucleus is charged. If they say the nucleus is positively charged, we ignore the reference to positive but if they just say it is positive, they will not get the mark.

- Most of the alpha particles went straight through.
- Some alpha particles were ~~delflect~~ deflected at an angle less than 90°.
- Some alpha particles were totally reflected back.

This shows that :-

- Most of the atom is empty space
- All the mass is concentrated in a small part of the atom (cetre also known as the nucleus)
- This part of the atom is charged.

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Examiner Comments

An example of a five mark answer that is well written and clear to follow.

and properties of the nucleus.

observations (5)

Most particles went straight through

Few deflected at large angle

Very few reflected back

Reason

Atom is mostly empty spaced

All charge is concentrated at a point

All the mass and charge concentrated at a single point in a small nucleaus

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Examiner Comments

This candidate states that all of the mass and all of the charge is in the nucleus, so has forgotten the electrons and so lost 2 marks.

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Examiner Tip

Don't forget the electrons when talking about Rutherford's experiment. You can say most of the mass but not all of the mass.

Most alpha particles reached the other side with close to no deviation from their trajectory ∴ most of the atom is empty space but some were deviated by a large angle ∴ meaning most of the charge was concentrated in one place. Also, some particles had changes of over 90° in their trajectory and rebounded back to the source meaning that also most of the mass of the atom is concentrated in one place. This results meant that there were points were most of the mass and charge were concentrated : the nucleus.

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Examiner Comments

This candidate says that most went through with close to no deviation. This is wrong. Also when referring to the atoms that rebounded, there is no idea that the number is very small, so again 2 marks have been lost.

Question 12

The interaction in this question was also tested in the January paper but as part of a longer question. In that question the quark formation of the omega particle was examined in the first part and so when the quark combinations for all of the particles was examined, it was decided that it would be wrong to assess the same fact twice and so the quark combination of the omega was not marked in the January examination. That was not the case in this paper; this was a short four mark question and candidates needed to correctly identify all five particles to score full marks. Some candidates who had rote learnt the mark scheme from January chose to omit the omega particle and so lost one mark. We are well aware that candidates memorise mark schemes but this is very much to be discouraged since there is no guarantee, as in this case, that exactly the same mark scheme will apply to another paper.

Some candidates misremembered the quark combination of the proton and others did not pick up on the clue that strangeness is conserved which meant that each of the kaons had to have a strange or antistrange quark in their composition.

$K^- = \bar{u}s$

$P = uud$

$K^+ = u\bar{s}$

$K^0 = d\bar{s}$

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Examiner Comments

Everything is correct but candidate has omitted the omega particle and so scores 4 marks.

$K^- = (\bar{u}d)$

$p^+ = (uud)$

$\Omega^- = (sss)$

$K^+ = (u\bar{d})$

$K^0 = (u\bar{u})$ or $(d\bar{d})$

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Examiner Comments

This candidate has focussed on charge conservation and has ignored the reference to strangeness being conserved. This means that all the kaons are incorrect so only scores 2 marks for the proton and omega.

Question 13

Most candidates appreciated that this question was about electromagnetic induction and three marks could be achieved by talking about the coil being in a changing magnetic field, referring to an induced e.m.f. and by identifying that the induced e.m.f. was proportional to the rate of change of flux linkage. The other two marks required references to the graph. However many candidates failed to recognise that this was not the same as the question from a couple of years ago, where a magnet fell completely through the coil and out the other side. The change of polarity in that case was due to one pole going into the coil followed by the other pole being closest as the magnet left the coil. In this question the change in direction of the e.m.f. is due to the change in direction of movement of the magnet. Candidates found it difficult to express this well enough to be awarded the mark. A more straightforward mark was to recognise that at the points when the magnet's speed was zero, the induced e.m.f. was zero. Quite a few candidates stated that the magnet had a fixed frequency but failed to state that the frequency of the magnet was the same as the frequency of the induced e.m.f. The majority of candidates did refer to/ included e.m.f. in their answers. A lot of candidates spent a lot of effort writing about Lenz's law but the effect of Lenz's law is insignificant in this context.

As the bar magnet enters the coil, the magnetic flux linkage changes, and more flux lines cut the coil, ~~changing~~ this changing magnetic field induces an ~~[illegible]~~ emf in the coil, causing the initial rise of voltage in the ~~reading~~ graph. When the magnet stops moving the magnetic flux linkage stops changing and the induced emf is zero. After that, the spring pulls the bar magnet back up, causing a changing magnetic flux linkage which induces an emf in the opposite sense as in the beginning, as the magnet is moving in the opposite direction. The spring is oscillating at a constant frequency, so the cycle repeats itself every 1.0s. The changing magnetic flux linkage induces an emf by $\varepsilon = \frac{-dN\Phi}{dt}$

ResultsPlus

Examiner Comments

An example that scores 5 marks. Changing flux, induced e.m.f. positive and negative values, condition for zero values and frequency of magnet's oscillation.

As Faraday's law states "the magnitude of the emf is proportional to the rate of change of the flux linkage."

$$\varepsilon = \frac{-d\,N(\phi)}{dt} \rightarrow \phi = BA$$

Therefore if the flux linkage is varying (because the magnet is moving up and down the coil, ~~therefore~~ therefore the field lines are being cut), the emf will vary too.

The positive and negatives means that the ~~coil~~ magnet is moving, therefore in some places there will be more force than in others, and the direction of the voltage will vary depending on the direction of the force (Fleming's left hand rule). The speed will be changing too.

(Total for Question 13 = 5 marks)

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Examiner Comments

This scored 2 marks only. There is no reference to induced and the last five lines are too vague.

ResultsPlus
Examiner Tip

When answering a question about electromagnetic induction, you must refer to an induced e.m.f.

(5)

The bar magnet pass into and out the coil, there is a change of flux linkage. From Faraday's law, the magnitude of induced e.m.f is proportional to the rate of the change of flux linkage. And from Lenz's law, the direction of induced emf is such as oppose to change creating it. $\varepsilon = -\frac{d(N\phi)}{dt}$

Therefore the voltmeter reading varies as shown.

ResultsPlus
Examiner Comments

Three marks but there are no comments that relate to the graph.

Question 14 (a)

Half of the candidates were able to successfully complete this calculation with both methods in the mark scheme being used. A significant number of candidates (20%) forgot to double their value of the photon's momentum and so got a velocity of half the correct value. Less able candidates did not realise that they could use *λ =h/p* to calculate momentum and set up an equation of momentum before equal to momentum after in terms of mass and velocity. Candidates were then challenged about what value of mass to use. Some candidates did complex calculations based on the speed of light which would give the correct answers but the extra unnecessary steps are likely to lead to arithmetic errors. Some candidates decided to use the mass of the hydrogen atom as the mass of a photon. Needless to say this method did not score any marks.

(4)

$p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}}{640\times10^{-9}} = 1.0359\ldots\times10^{-27}\ kg\,m\,s^{-1}$

initial momentum = final momentum

$1.0359\ldots\times10^{-27} + 0 = -1.0359\ldots\times10^{-27} + 1.67\times10^{-27}\times V$

$V = \frac{2\times1.0359\ldots\times10^{-27}}{1.67\times10^{-27}}$

$V = 1.24\ m\,s^{-1}$

ResultsPlus
Examiner Comments

A well laid out correct answer that scores 4 marks.

$p = \frac{h}{\lambda}$

$= \frac{6.63\times10^{-34}}{640\times10^{-9}}$

$\approx 1.036\times10^{-27}\ Ns.$

$V = \frac{p}{m}$

$= \frac{1.036\times10^{-27}}{1.67\times10^{-27}}$

$\approx 0.62\ ms^{-1}$

Speed = $0.62\ ms^{-1}$

ResultsPlus
Examiner Comments

Common wrong answer. Candidate has found the momentum of the photon and equates it to the change in momentum of atom, so gets half the required value.

ResultsPlus
Examiner Tip

When a photon/particle rebounds with the same velocity after a collision, there is a change in momentum of 2p.

$\lambda = \frac{h}{p}$ $p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}}{640\times10^{-9}}$

$= 1.04\times10^{-27}\ \text{kg m s}^{-1}$.

$p = mv$

$m = \frac{1.04\times10^{-27}}{3\times10^{8}}$

$= 3.47\times10^{-36}\ \text{kg}$.

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$.

$3.47\times10^{-36}\times(3\times10^{8}) + 0 = -(3.47\times10^{-36})\times(3\times10^{8}) + (1.67\times10^{-27})\times v$

$v = \frac{1.041\times10^{-27}}{-1.041\times10^{-27} + 1.67\times10^{-27}} = 1.66\ \text{m s}^{-1}$

Speed = $1.66\ \text{m s}^{-1}$.

ResultsPlus
Examiner Comments

This candidate finds the momentum of the photon, divides by c to get a mass, substitutes into a mass velocity equation and multiplies by c. Theoretically this should work and candidates should get the correct answer but there is an arithmetic error and the answer is wrong.

Question 14 (b)

A lot of candidates invented a new conservation law, that of kinetic energy. Some candidates also wrote that there was more kinetic energy after the collision than before the collision, therefore it was an inelastic collision. Candidates need to realise that in an inelastic collision, the kinetic energy after the collision is always less than the kinetic energy before the collision. Also the candidates were instructed in (a) to apply the conservation of momentum and then in (b) to identify another conservation law. However, a significant number of candidates identified momentum. Most candidates were able to identify that there appeared to be an increase in kinetic energy, but only 10% of candidates were able to deduce that the wavelength would be different if recorded to more significant figures and only half of those stated that it would lead to an increase in wavelength.

The Law of conservation of ~~energy~~ kinetit energy. The incident photon, hit the stationary hydrogen atom. It provided it with a speed v. For this to happen energy must have been transfered from photon → hydrogen atom. So the wavelength of the photon coming back can't be the same.
If we recorded the wavelengths of proton in more significant values, he would have seen a decrease in wavelength, proving loss in energy kinetic.

(Total for Question 14 = 8 marks)

ResultsPlus
Examiner Comments

This candidate incorrectly refers to conservation of kinetic energy but does appreciate that there appears to be an increase in kinetic energy and that the wavelength should be different. Unfortunately, the candidate has not worked through the lower energy → lower frequency→longer wavelength process.

It is inconsistent with the law of conservation of energy. The energy of photon is the same for the photon before and the photon after, but the kinetic energy of the hydrogen atom increased. The energy of photon is $E = \frac{hc}{\lambda}$. This the means that the total energy of the system of photon and hydrogen atom increased by the KE of the hydrogen atom. Recoding the wavelength to more significant figures is necessary, as it is needed to show that the wavelength of the photon could be greater than 640nm, maybe 642.1nm, the increased wavelength would help justify that the hydrogen atom gained kinetic energy

(Total for Question 14 = 8 marks)

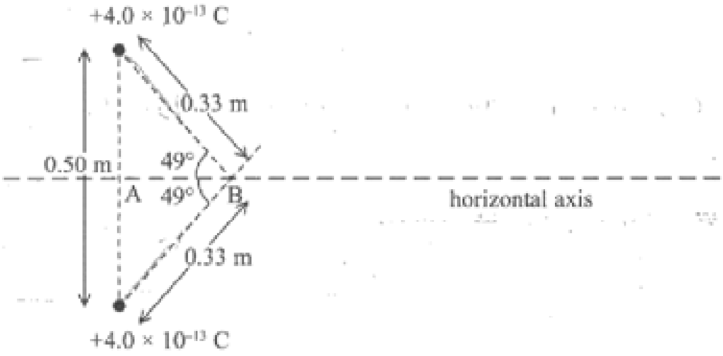
ResultsPlus

Examiner Comments

An example of an answer that scores 4

Question 15 (a)

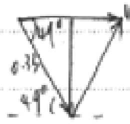
In past papers, where questions about point charges have been asked it has usually been to calculate the force between two point charges. This question required candidates to find the field at a point due to two point charges. Majority of candidates wanted to use the force formula which is incorrect. Other candidates, also incorrectly, wrote the force equation with the two charges multiplied and just equated it to E. Candidates obviously do not understand the difference between the three formulae for electric field strength that are printed on the formula sheet. It was also not uncommon to see Boltzmann's constant used as the value for k in the field equation. Even those candidates who appreciated that they were trying to find an electric field struggled to appreciate that the vertical components of the two fields would cancel and that the two horizontal components would add together. This meant that there needed to be a factor of cos 49 and a factor of ×2. Candidates who tried to answer the question with a force, were allowed to score the marks for these two factors. Generally candidates struggled when dealing with the electric field due to points charges.



(a) Calculate the resultant electric field strength at B, a distance of 0.33 m from each charge.

(4)

$E = \frac{kQ}{r^2} = \frac{8.99\times10^{9} \times 4.0\times10^{-13}}{0.33^2} = 0.0330\ \text{V m}^{-1}$



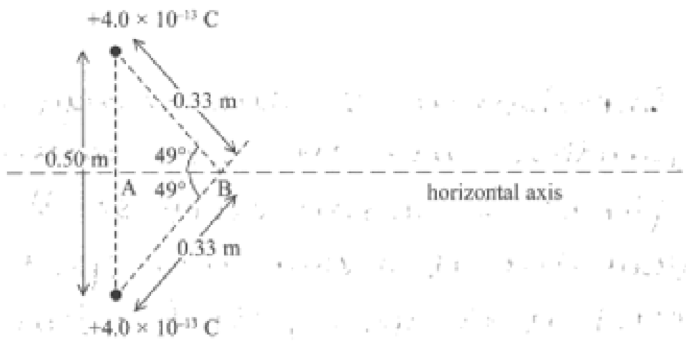
$2 \times 0.0330 \times \cos 49^\circ = 0.0433\ \text{V m}^{-1}$

Resultant electric field strength = $0.0433\ \text{V m}^{-1}$

ResultsPlus

Examiner Comments

An example of a correct calculation.



(a) Calculate the resultant electric field strength at B, a distance of 0.33 m from each charge.

(4)

$E = \frac{kq_1q_2}{r^2}$

so $E = \frac{8.99\times10^{9} \times 4\times10^{-13} \times 4\times10^{-13}}{(\cos 49 \times 0.33)^2}$

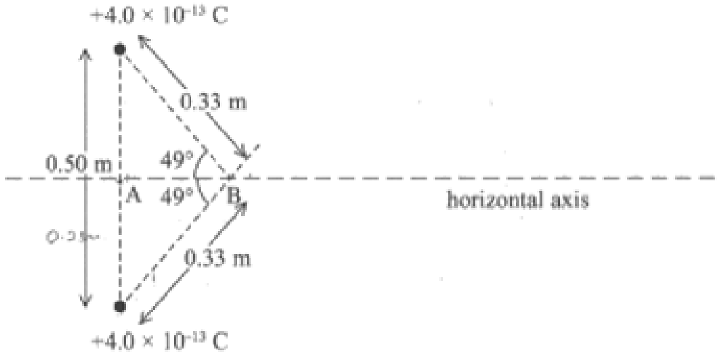
~~= 0.077 N~~

~~Total = 0.077 + 0.077 = 0.153~~

Resultant electric field strength = $0.033\ \text{N C}^{-1}$ $0.15\ \text{N C}^{-1}$

ResultsPlus
Examiner Comments

A typical answer where the candidate has used the force equation with the symbol E. This candidate has also failed to understand that you need to find the value of E at a distance of 0.33 m and then take the horizontal component rather than find cos 49 × 0.33, which is an incorrect distance.



(a) Calculate the resultant electric field strength at B, a distance of 0.33 m from each charge.

(4)

$E = \frac{kQ}{r^2} = \frac{8.99\times10^9 \times 4.0\times10^{-13}}{0.33^2} = 0.033\ Cm^{-2}$

Resultant electric field strength at B = $0.033 + 0.033$

$= 0.066\ Cm^{-2}$

Resultant electric field strength = $0.066\ Cm^{-2}$

ResultsPlus
Examiner Comments

This candidate has found the electric field strength and doubled it but has not found the horizontal components. This scored 2 marks.

Question 15 (b)

The most common score for this question part was zero. Of the two marks, more candidates were able to identify that the electric field obeys an inverse square law but not many candidates could state that at A the two fields were equal and opposite. The most common answers were that it was zero because it was a neutral point or because the fields cancelled. A significant number of candidates chose to just write about either why the field is zero at A or about the value at large distances, despite the fact that the question asks for both.

(2)

As E from both charges is equal when ~~directly~~ between them you have the same E acting upwards and downwards ∴ cancelling out at large distances $E = k\frac{Q}{r^2}$ r increases ∴ E decreases.

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Examiner Comments

This candidate has the idea of opposite directions but does not mention magnitude. This scores 1 for the inverse square statement.

At A, both fields produced by the two charges have equal magnitude but are opposite in direction. Therefore, they cancel out each other and no resultant electric field is present at A.

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Examiner Comments

The first sentence scores the mark. However there is no mention of why the field decreases at large distances. Scores 1 mark.

ResultsPlus
Examiner Tip

Read the question carefully and make sure you answer all of the parts.

At point A there is no resultant electric field
So it is zero.
Electric field strength is ~~proportional~~ inversely proportional to the square of distance. So when the distance increase the value of E_R decrease

ResultsPlus
Examiner Comments

This candidate just explains that zero means there is no electric field and this is not an explanation of why it is zero. Another 1 mark answer.

Question 15 (c) (i)

This part was generally well answered with candidates able to use F = QE with F = ma using the data provided in the question part. The examples show the types of mistakes made by those who did not score full marks.

(3)

$F = Eq \quad ma = Eq \quad a = \frac{Eq}{m} = \frac{0.044 \times 1.6\times10^{-19}}{6.6\times10^{-27}} = 1.1\times10^{6}\ m/s^2$

this is max acceleration as E is max at C

Maximum acceleration = $1.1\times10^{6}\ m/s^2$

ResultsPlus
Examiner Comments

The charge on the ion was given in the question but some candidates chose to use the charge on an electron. This scored 1 mark for the use of F = ma

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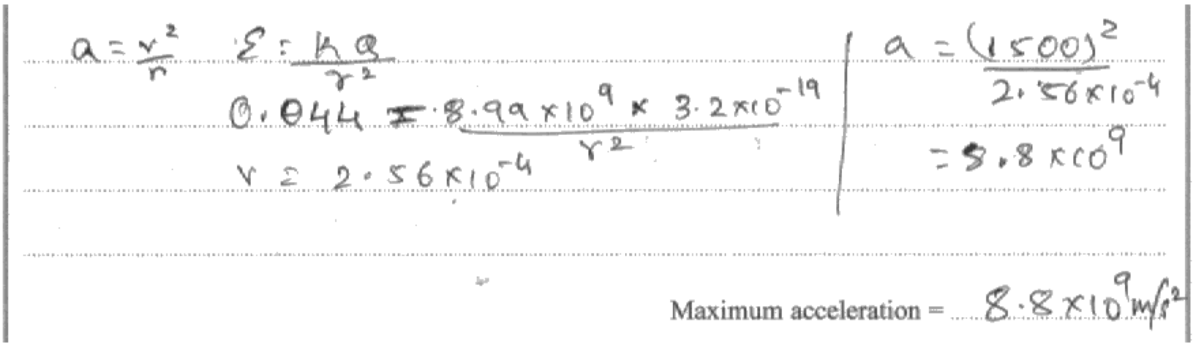
Examiner Tip

Read the question carefully and use the data provided.



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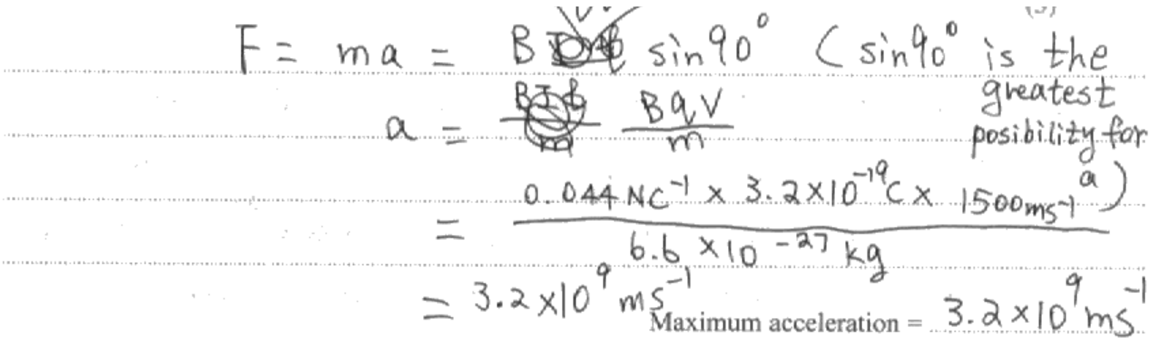
Examiner Comments

This candidate thinks there is circular motion and so uses the value of E and Q to find a value to substitute into the circular acceleration formula. This candidate does not appreciate that the electric field is produced by another charge and not the charge that is entering the field.



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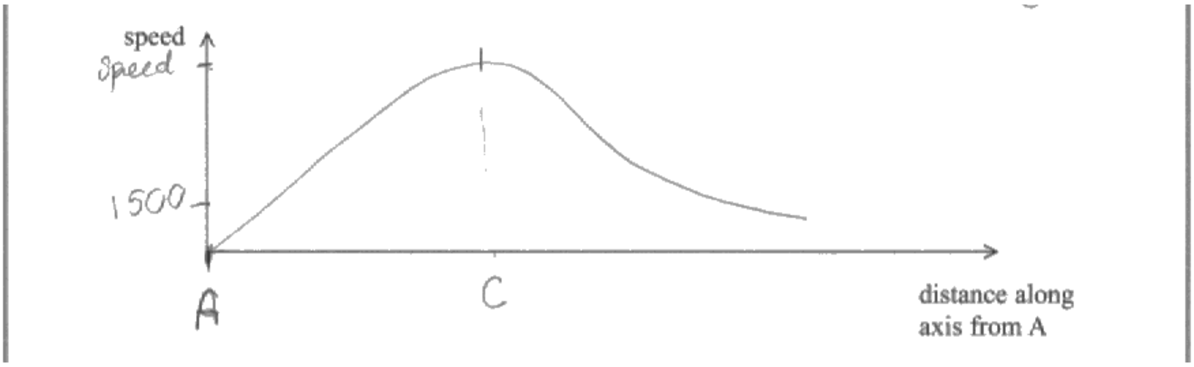
Examiner Comments

This candidate decides to use all of the data in (i) including the speed, which was needed in (ii). In order to use all of the data, the candidate has used the formula for a magnetic field, despite this question being about electric fields.

Question 15 (c) (ii)

This is probably the most conceptually difficult part of the paper. Candidates needed to realise that at all distances there was a positive field acting and so the ion would always experience a force and an acceleration over the distance shown. The ion has a speed at point A and so there should be a non zero value of speed at A and the speed should increase continually from that point. The rate of increase varies with a maximum at C but at no time would the speed decrease.



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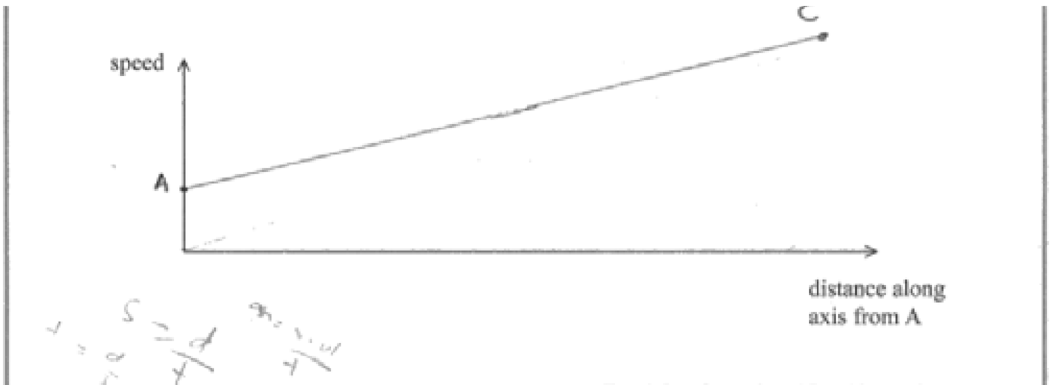
Examiner Comments

The most common wrong answer. The candidate has even marked in the 1500 but starts the graph at zero, the acceleration becomes zero at C instead of a maximum and then the speed decreases, despite there still being a resultant accelerating force. Effectively all the candidate has done is copy the shape of the force graph.

Question 1



(Total for Question 15 = 12 marks)

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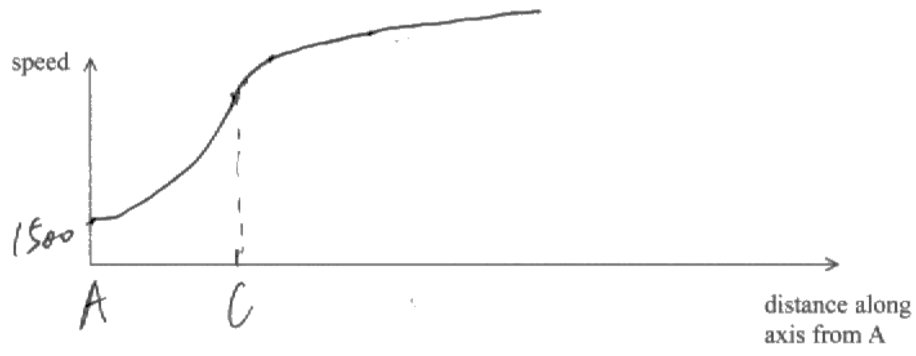
Examiner Comments

This candidate has not put any values on the y axis so we can't tell that this is a non zero start but at least it has a continually increasing speed but one that would be produced by a constant field. This scores 1 mark.



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A rarely seen perfect answer that scores 3 marks.

Question 16 (a)

The straightforward answer that the string cannot be horizontal because there must be a vertical component of tension to balance the downward weight of the mass was rarely seen. In fact, it was surprising how few of the candidates managed to mention the fact that weight acts vertically downwards. Most candidates just seemed to focus on the horizontal motion, relating tension to centripetal force and showing that they did not understand that a centripetal force is resultant of a physical force. In this case the horizontal component of tension, the string, cannot be horizontal otherwise it would provide all of the centripetal force. A worrying number of candidates seemed concerned about the fact that the string would hit the person's arm.

Because the string (Tension) provides the centripetal force that keeps the mass in the path. At the horizontal positions, the weight is at 90° to the tension of the string acting downwards. Thus is difficult to keep it horizontal. (Tension is Zero)

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This candidate does appreciate that the weight acts vertically downwards but makes no link for the need for a vertical component of tension to balance it.

Because the weight acts dowards so you need a vertical component of tension to keep it in constant velocity, the string ~~it~~ can't only be horizontal

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Examiner Comments

A 2 mark answer.

~~The string will break~~ For the string to be horizontal, there has to be a large centripetal acceleration. The string will ~~be~~ break under this force.

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Examiner Comments

A typical wrong answer.

Question 16 (b) (i)

This question was generally well answered with 40% of candidates scoring all four marks and 70% being able to calculate the necessary resultant physical force that acted as the centripetal force. It required candidates to calculate the resultant force and then use resultant force = tension + weight, to determine the tension in the string. A significant number of candidates added the weight to the resultant force, rather than subtracting it. For the small number of candidates who did not score well on this question, the common mistake was to use $F = mv^2/r$ but then substitute ω as v.

$F = \frac{mv^2}{r}$, $F = \frac{m\omega^2 r^2}{r}$, $F = m\omega^2 r$

$\therefore F = (0.204)(9.90)^2 (25/100)$

$F = 4.99\,N \approx 5.0\,N$

ResultsPlus

Examiner Comments

This candidate has found the resultant force but has ignored the weight of the mass.

At the top, $T = mg + \left(\frac{mv^2}{r}\right)$ $\quad v = \omega r = 9.9 \times \left(\frac{25}{100}\right) = 2.475\,ms^{-1}$

Weight $= mg =$ ~~204 × 9.81 = 2~~ $0.204 \times 9.81 = 2.00\,N$

$F_c = \frac{mv^2}{r} = \frac{(0.204)(2.475)^2}{0.25} = 4.999\,N$

$T = W + F_c = 2 + 4.999 = 6.999 = 7\,N$

Tension = 7N

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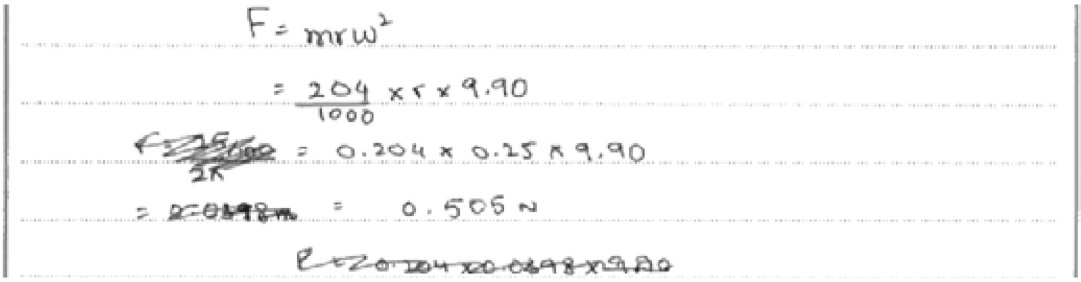
Examiner Comments

A common error. The candidate has used the condition for the bottom of the swing rather than the top and so has added the weight rather than subtracting it.


$F = mr\omega^2$

$= \frac{204}{1000} \times r \times 9.90$

$= 0.204 \times 0.25 \times 9.90$

$= 0.505\ N$

ResultsPlus
Examiner Comments

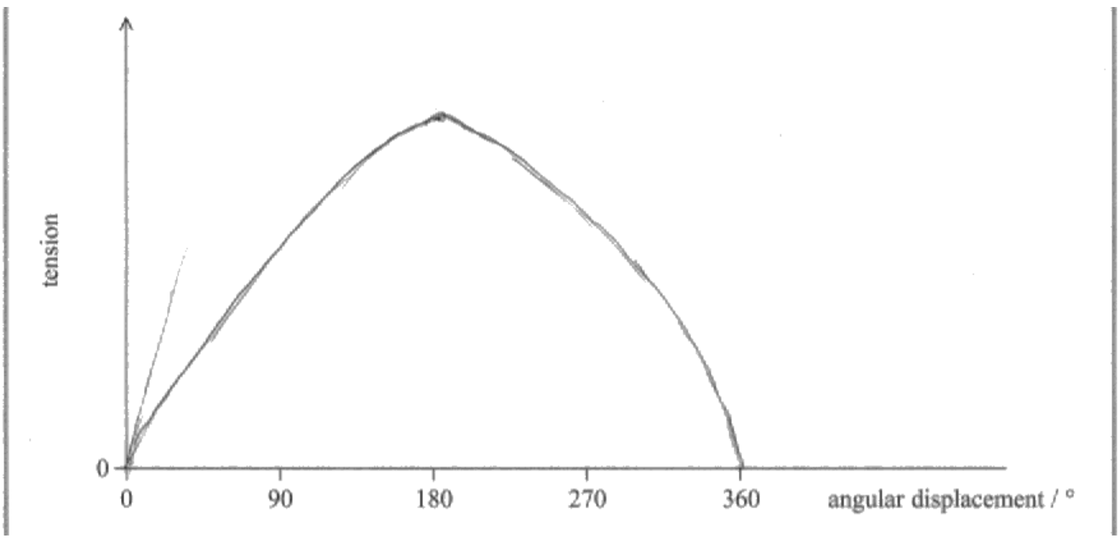
This candidate has used the correct formula but has forgotten to square the ω term which was a common error.

ResultsPlus
Examiner Tip

The difficult part is often identifying the equation to use. Having got this correct, take care to make sure you use the equation correctly.

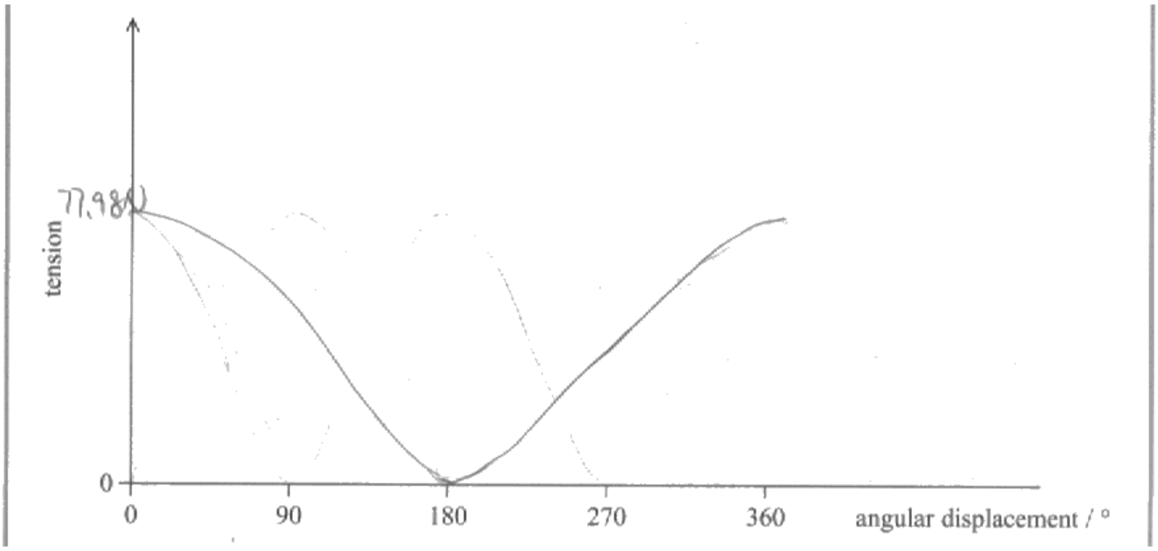
Question 16 (b) (ii)

This was another question part that was often well answered with the majority of candidates scoring 3 or 4 marks. The two mistakes that were most common, was to have a zero value at 0° and 360° and to have a negative gradient at the beginning. We ignored the values used for force since wrong values were penalised in the previous part. We were just looking for evidence of a non zero start.



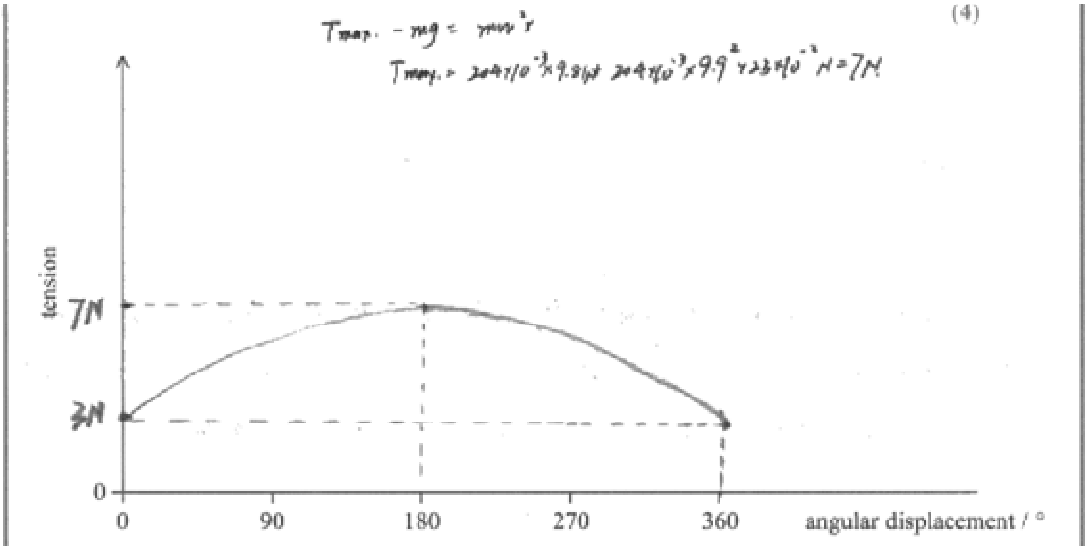
ResultsPlus
Examiner Comments

A zero start so this scored 3 marks.



ResultsPlus
Examiner Comments

A negative initial gradient and a non zero trough so this scored 2 marks for the initial and final points.



ResultsPlus
Examiner Comments

A four mark answer. We accepted either straight lines or curves between the points.

Question 17 (a)

Candidates do not seem to know the definition of a magnetic field. The majority of candidates could identify that, as with all fields, it is a region where a force is exerted but very few could identify that it was the force on a moving charged particle. It cannot be emphasised enough how important it is to learn definitions. Only a small percentage of candidates scored both marks.

(2)

A field that has a force acting on any charged particles ~~with electricity~~

ResultsPlus
Examiner Comments

This scored zero. There is no reference to a region or area where the force acts and although a charged particle is mentioned, there is no reference to it moving.

Magnetic field is defined as a region in which moving charged particles experience a force at right angles to their motion and magnetic field.

ResultsPlus
Examiner Comments

This scores 2 marks although the information about the direction is not needed.

Question 17 (b) (i)

Candidates needed to apply Fleminng's left hand rule to identify that the charge on the particle is negative.

Question 17 (b) (ii)

The path of the particle in the magnetic field is circular and is explained because the magnetic force on the particle is always at right angles to its direction of motion. We did not accept curved as a description because it is too vague. We did not accept 'the force acts as a centripetal force' for the explanation because it can only act as a centripetal force; the force is at right angles to the direction of motion.

When the particle enters the field, it experiences a centripetal force perpendicular to its direction of motion (downwards). The particle therefore carries out ~~an~~ ~~arc~~ path ~~the path~~ a path in the form of an arc.

ResultsPlus
Examiner Comments

The particle does not experience a centripetal force. It experiences a magnetic force which acts as a centripetal force. An arc is not acceptable as a description of circular motion since you can have an arc of a parabola. This scores 0.

As the particle enters the magnetic field it experiences a magnetic force which causes it to deflect ~~its~~ from its path and move in a curved path.

ResultsPlus
Examiner Comments

Another example of an answer that did not score any marks. There is no mention of the force being at right angles to the direction of motion of the particle, and curved is not acceptable for circular.

Question 17 (b) (iii)

Just over 50% of the candidates were able to use the formula F = Bqv with the formula F = mv^2/ r to derive the required expression. The majority of incorrect answers just wrote down r = p/Bq p=mv so r = mv/Bq. i.e. they took the answer made one change and then reversed the change.

~~Mv^2r~~ $\frac{mv^2}{r} = Beq$

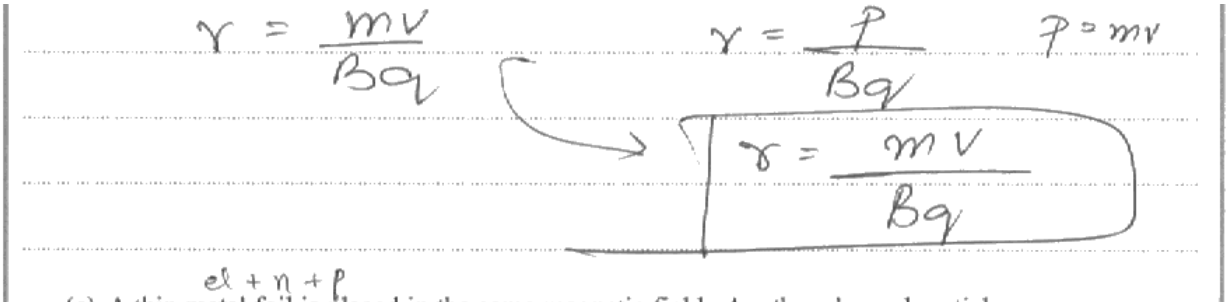
$\frac{r}{mv^2} = \frac{1}{Beq}$ $r = \frac{mv^2}{Beq} = \frac{mv}{Bq} \times \frac{v}{e}$

$\therefore$ $r = \frac{mv}{Bq}$

(c) A thin metal foil is placed in the same magnetic field. Another charged particle

ResultsPlus
Examiner Comments

This candidate uses the centripetal force equation but has e and q on the right hand side and no v. The equation is rearranged accurately until the last step, where the extra v and e are just omitted. Needless to say this scored 0.



ResultsPlus
Examiner Comments

An example of taking the answer, adjusting it with p = mv and finishing with what the candidates started with.

This question was about charged particles in magnetic fields so the derivation of any equation about this motion must involved $F = mv^2/r$

Question 17 (c) (i-ii)

In (c)(i), the significant point that candidates should have observed was that the radius of the particle changes dramatically as the particle passes through the foil. The equation in (b)(iii) showed candidates that for a constant field, mass and charge, the radius of the particle's path is directly proportional to the particle's velocity.Candidates were expected to deduce that the particle has lost energy going through the foil, with velocity and radius decreasing hence being able to determine the direction of travel of the particle. The majority of candidates completely ignored the foil and made no reference to it at all and gave general answers about the particle losing energy and the radius decreasing. That was a suitable answer to explain a spiral where the radius is continually decreasing but not in this situation, where there is one point where there is a specific discontinuity in the radius. By not mentioning the foil, candidates lost 2 marks.

In (c)(ii), candidates were again expected to use the formula in (b)(iii) to appreciate that momentum was directly proportional to radius in order to calculate the ratio of the momenta so that $p_1/r_1 = p_2\, r_2$. Candidates were expected to work out the value of 6.1/8.4 and not leave it as a ratio. Many candidates were not able to do this.

the radius of the circle decreased. The particle lost energy. and a particle cannot gain energy from nothing

(ii) The radii of the two sections of the path are 8.4 cm and 6.1 cm.

Determine the ratio of the final momentum of the particle to the initial momentum of the particle, as it passes through the foil.

(2)

$p = Bqr$ B and q are constant

r is changing

$\frac{P_1}{P_2} = \frac{r_F}{r_2} = \frac{6.1\text{ cm}_F}{8.4\text{ cm}_I} = 0.73_F : 1_I$

Ratio = 0.73 : 1

ResultsPlus

Examiner Comments

This candidate scored 1 and 2. There is no mention of the foil.

When a particle passes through the foil, it loses momentum and so the path's radius decreases ($r = \frac{p}{Bq}$). The magnetic field and the charge remain the same.

(ii) The radii of the two sections of the path are 8.4 cm and 6.1 cm.

Determine the ratio of the final momentum of the particle to the initial momentum of the particle, as it passes through the foil.

(2)

Initial momentum => $p = 8.4Bq$, Momentum after passing through foil => $6.1Bq$. Ratio => $\frac{6.1Bq}{8.4Bq} = 6.1 : 8.4$

Ratio = 6.1 : 8.4

ResultsPlus

Examiner Comments

This candidate scored 3 and 1. Leaving the answer as 6.1:8.4 is like giving the answer as a fraction which we never accept for the answer mark. Strictly speaking they should write it as 0.73:1 but we were prepared to accept just 0.73

Question 18 (a) (i)

It was obvious from the answers to 18(a)(iii), that candidates need not think about the circuit that was in this question before they started to answer it. Most candidates appreciated that the starting point had the capacitor charged but they did not notice that the resistor was in the discharging circuit but not the charging circuit. This was significant for (iii) but candidates should look at a circuit analytically before they start answering the questions. For (a)(i) it was an two easy marks, looking for the fact that the capacitor discharges and secondly, that this happens over a time interval.

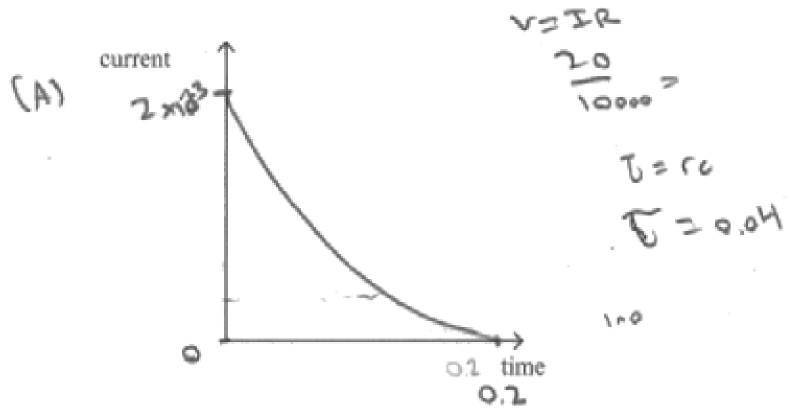
the capacitor discharges slowly through the 10kΩ resistor.

ResultsPlus
Examiner Comments

This scored 2 marks, the use of the word slowly implies a time interval.

Question 18 (a) (ii)

Not many candidates scored all three marks here and the likelihood of scoring each mark went in the order of the mark scheme. Shape of graph and cutting y-axis but not x-axis, were most often scored. Adding the initial current of 2 mA was next and then a sensible time such as the time constant 0.04s in approximately the correct point was the lowest scoring mark. Many candidates did not realise that the phrase 'indicate typical values of current and time' meant that the values had to be specific to this circuit and values given.



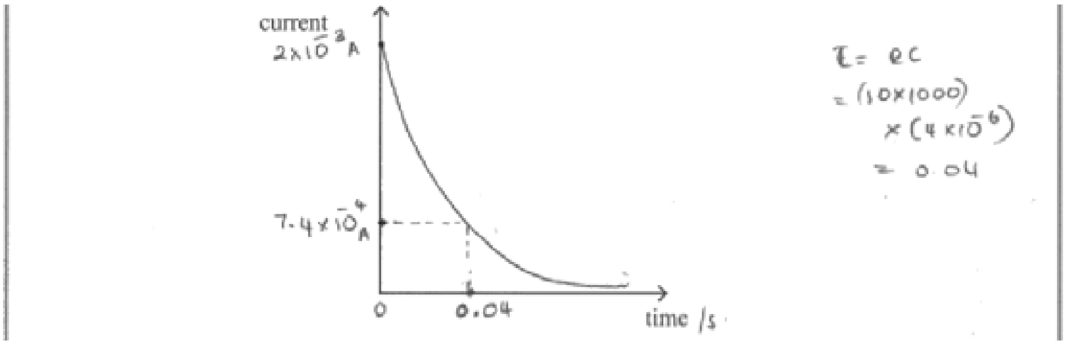
ResultsPlus
Examiner Comments

This candidate did not get the shape mark because their graph touches the x-axis. It scored the other two points. We accepted 0.2 s as a time when there was negligible current flowing.

ResultsPlus

Examiner Tip

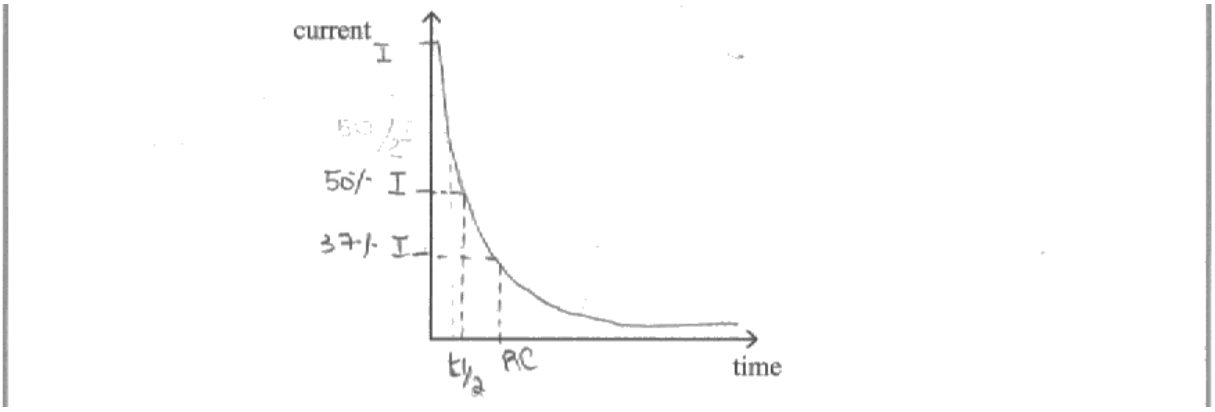
Remember that an exponential graph must touch the y-axis but never the x-axis.



ResultsPlus

Examiner Comments

An example that scored all three marks although there was no need to add the current at the time of 0.04 s.



ResultsPlus

Examiner Comments

This scored 1 mark for the shape. This candidate does understand what happens in an exponential graph but has not answered the question because there are no actual values given.

ResultsPlus

Examiner Tip

Typical values means numbers such as 2 mA or 0,04 s.

Question 18 (a) (iii)

As mentioned earlier, hardly any candidates noticed that there was no resistance in the charging circuit. The three marks were for identifying a charging process which happened instantaneously because there was no resistance. Only 4% of candidates noticed that there was no resistance. Candidates realised that there wouldn't be 3 marks for just saying that the capacitor charged up and so wrote quite eloquently, but with no credit, about the process and the electrons.

The capacitor begins to charge. Its voltage increases exponentially until it equals to the voltage of the battery (20V). ~~Charging is~~ The charging process happens immediately as there ~~are~~ are no resistors in the charging circuit. ~~The graph for of current in am~~ The graph of current stays the same as in (a) (ii) during charging.

ResultsPlus
Examiner Comments

An example of one of the few candidates who made the correct deductions.

The capacitor charges up. ~~until~~ The reading in the ammeter will decrease from a maximum to close to zero as ~~charge~~ ~~and voltag~~ pd across the capacitor and charge stored decreases.

ResultsPlus
Examiner Comments

A typical 1 mark answer.

Question 18 (b)

This was well answered with almost half of candidates scoring all three marks. One error that did occur was to use 20V as the final voltage rather than as the initial voltage. Some candidates wanted to use the $Q = Q_o e^{-t/RC}$ which is the exponential formula given in the paper. It was possible to do the calculation by this method but there were was an increased chance of making a mistake as usually happened. This was done by the less able candidates who did not realise that the exponential formula can be used with quantities other than charge. The other mistake that was made was candidates correctly calculating the value of 0.13 V but then proceeding to subtract this from 20V. This meant they could not score the final answer mark.

(b) The student wants to use this circuit to produce a short time delay of 0.20 s after the switch moves from X to Y.

Calculate the value of the potential difference across the capacitor after this time interval.

(3)

$V = 20\, e^{-0.20/4\times10^{-6} \times 10000}$

$= 12.1$ V

so one plate in positively charged and another plate is negatively charged.

Potential difference = 12 V

ResultsPlus

Examiner Comments

This candidate has set up the calculation correctly including the unit conversions but gets the wrong answer. This is either a candidate who is not sure how to use the calculator or perhaps did not have a calculator at all.

ResultsPlus

Examiner Tip

At A2 you can expect to have to do an exponential function calculation. Make sure you know how to use your calculator to do this.

~~t = RC = 10×10³ Ω × 4×10⁻⁶ F = 0.04s.~~

$V = V_0 e^{-\frac{t}{RC}}$

$= 20V \times e^{-\frac{0.20s}{10\times10^3\Omega \times 4\times10^{-6}F}}$

$= 0.13$ V.

∴ potential difference across the ~~capici~~ capacitor = 20 − 0.13 = 19.87 V.

Potential difference = 19.87 V

ResultsPlus
Examiner Comments

An example of the common wrong answer where the candidate subtracts the correct answer from 20V.

Question 18 (c)

Generally this was well answered with the majority of candidates being able to calculate the two energy values. Where errors were made, it was after having written the equation correctly, the candidates failed to square the velocity of the potential difference. Other candidates failed to realise that they needed to use $W = CV^2/2$ for the capacitor. As with Q17(c)(ii), candidates struggled with the idea of a ratio. They do not seem to realise that the ratio is the energy stored on the ultra capacitor divided by the kinetic energy of the car. Only half of the candidates who successfully found the two energies went on to score the third mark.

KE Car $= \frac{1}{2}mv^2 = \frac{1}{2}(800)(30)^2 = 360{,}000\ J$

~~KE~~ Energy in capacitor $= \frac{1}{2}cv^2 = \frac{1}{2}(2600)(2.5)$
$= 3250\ J$

Ratio $\frac{\text{Stored}}{\text{K.E}} = \frac{3250}{360{,}000} = \frac{13}{1440} = 9.02\times10^{-3}$

Ratio = 9.03×10^{-3}

ResultsPlus
Examiner Comments

This candidate forgot to square the 2.5 in the capacitor equation so again this scores 1 mark.

ResultsPlus
Examiner Tip

Take care, when using an equation that you square terms when needed.

$\omega = \frac{1}{2}CV^2 = \frac{1}{2}(2600)(2.5)^2 = 8125J$

E_k of car $= \frac{1}{2}mv^2 = \frac{1}{2}(800)(30)^2$

$= 360,000J$

E_k of car : energy in capacitor

360,000 : 8125

576 : 13

Ratio = 576 : 13

ResultsPlus

Examiner Comments

This candidate scores 2 marks for the energy calculations but gets the ratio the wrong way round and so does not score the answer mark. Even if the ratio had been written as 13:576 the mark would still not have been awarded, we were looking for a complete answer which is 0.023:1 or just 0.023

Paper Summary

Based on their performance on this paper, candidates are offered the following advice:

- Candidates need to memorise definitions.
- Candidates should ensure that when doing calculations, they remember to include processes such as squaring and square roots when needed.
- Although looking at past papers and mark schemes can be beneficial, it is worth remembering that a mark scheme indicates the minimum requirement for that specific paper and it cannot be guaranteed that a similar question on a future paper would be marked in the same way.
- Also questions on a specific topic can be worded differently to assess different aspects of that topic and so candidates need to read the question carefully.
- Always answer the question that is being asked not one that was asked in a previous series.

Grade Boundaries

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

http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx

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