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Examiners' Report
June 2014

GCE Physics 6PH04 01

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Introduction

This paper was generally well answered with candidates able to attempt all question parts and demonstrate a good understanding of the physics that was being tested. All of the question parts were accessible to the majority of candidates and all of the marks were awarded to some candidates. There were a number of question parts that were more challenging and these provided good discrimination across the paper. At the A grade boundary candidates generally scored well with quite a few gaining ten marks. The average score at the E boundary was six.

Question	**Topic**	**% correct**	**Common wrong answer**
1	Force time graph	87	-
2	Inelastic collisions	81	C
3	de Broglie equation	94	-
4	Atomic structure	90	-
5	Induced emf calculation	70	B/D
6	Electron path in electric field	67	A/B
7	Magnetic force calculation	82	B
8	Use of $F = Bqv$	51	D
9	units	68	C
10	Circular momentum	54	B

The two questions that scored the lowest mark were ones where candidates needed to write down equations in order to work out the answer. Question 8 required them to use $F = Bqv$ but as well as the factor of ten for the velocity and 0.5 for the magnetic flux density, candidates needed to think about q and appreciate that the beta particle has half the charge of the alpha particle. It was forgetting about the charge factor that led to the common wrong answer of D. For question 10 candidates could have thought about the equation $F = mv^2/r$ and substituted for $v = rw$ for one of the v to show that answer B was correct. However B was often chosen presumably because they had never seen it written in that from and so assumed it was wrong. However without deriving the equation they should have realised that answer A could not be correct because it is dimensionally wrong.

Question 11

This was a straightforward question requiring the application of conservation of momentum, although credit could be gained by answering in terms of Newton's third law of motion. Nearly all candidates understood the physics of the question with 37% scoring the full four marks and 27% scoring three marks. Candidates often demonstrated a recall of the principal of conservation of momentum but they needed to apply it to the context of the question. A common mistake was to omit saying that the initial momentum was zero. The idea of equal and opposite momentum change was generally well expressed but the use of a different direction is not specific enough. The appropriate use of equations with defined terms could score marking points 1 and 2 but often candidates used ambiguous m v and p which did not refer to anything specific.

Because before the nuclear decay the momentum of the nucleus is 0 as $p=mv$ and velocity is 0. However when the alpha particle is emitted it has gained momentum. Because momentum must be conserved as there are no external forces, the nucleus must also gain an equal amount of momentum but in the opposite direction so the sum of the two momenta is still equal to zero. The speed of the nucleus after the decay is slower than that of the alpha particle is because the nucleus is much more massive. As $p=mv$ where momentum gained is equal for both, $m \propto \frac{1}{v}$. So the more massive nucleus has a slower velocity than the lighter alpha particle.

(Total for Question 11 = 4 marks)

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Examiner Comments

This response is a clear well written answer that scores full marks.

The nucleus recoils because momentum ~~must~~ is be conserved.

The mass of the radium nucleus is greater that the mass of the emitted alpha particle, therefore the speed of the recoiling nucleus will be less than the speed of the alpha particle.

Momentum = mass x velocity

∴ Momentum for alpha particle = momentum of nucleus

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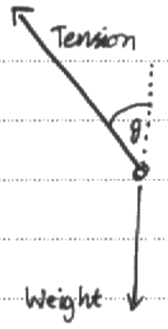
Examiner Comments

This candidate makes a general statement about conservation of momentum which does not score a mark. The focus is then on the mass difference and at the end there is a statement about the two momenta being equal so this answer scores 2 marks. There is no mention of initial momentum being zero or that the nucleus and alpha particle move in opposite directions.

Question 12

The free body force diagrams were very poor with many candidates adding a centripetal force. The other error was that having drawn a tension force, candidates then added two component forces thus implying that there were four forces acting. Candidates needed to appreciate that having drawn a free body force diagram, they needed to resolve the tension horizontally and vertically to derive two equations. Those who did this were generally successful. However many candidates wasted time by writing long involved answers that were not based on the components and which scored no marks. The most frequently awarded marks were 2 and 1, with only 12% of candidates scoring 5 marks.



If you resolve vertically ① $T\cos\theta = mg$.
If you resolve horizontally the resultant force is a centripetal force so
② $T\sin\theta = \dfrac{mv^2}{r}$

Solving for θ gives ② ÷ ① $\Rightarrow \boxed{\tan\theta = \dfrac{v^2}{gr}}$

Therefore (because mass cancels out) θ depends on ~~the~~ speed of rotation, g (a constant) and the radius of the circle

The weight acts at 90° to the centripetal force so it doesn't affect it.

(Total for Question 12 = 5 marks)

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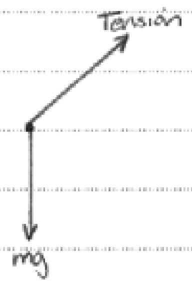
Examiner Comments

This candidate scores all 5 marks. It shows a correct diagram, tension force resolved and equated. Clear derivation of formula and statement.



The mass of the rider stays constant as the fairground ride begins to spin, however, the angle ~~of~~ to the verticle of the support ropes increases. As the fairground ride begins to spin the tangential velocity of the chair and rider increases. As $v = \omega r$, where ω is constant, the radius of the circular path increases. The angle ~~of~~ to the vertical of the supporting ropes ~~[illegible]~~ increases as r increases as the length of the support rope remains constant.

(Total for Question 12 = 5 marks)

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Examiner Comments

Another correct diagram but this candidate does not derive an equation and so does not score any marks for the written part of the answer.

If you are asked to show whether or not one variable depends on another variable you must derive an equation to base your answer on.

$F = \frac{mv^2}{r}$

$T\,\cancel{\sin}\cos\theta = mg$

Mass cancels out as it is pressent in both equations where as velocity is not

The chair and rider are always accelerating and r will change as v changes.

Tension will be affected by v as there will need more horrizontal force to act on the chair.

(Total for Question 12 = 5 marks)

ResultsPlus
Examiner Comments

Another common error, the addition of a third force called a centripetal force. This candidate does correctly identify the vertical equation but not the horizontal one.

There is no physical force called a centripetal force. Circular motion is cause by a resultant force at right angles to the direction of motion of the object. In this example it is the horizontal component of tension that can be equated to mv^2/r.

Question 13 (a-b)

This was well answered with 63% of candidates scoring the full 5 marks. Despite having the equation $E = p^2/2m$ to use directly, many candidates chose to use $E_k = mv^2/2$ and $p=mv$. This will give the correct answer but often candidates made an arithmetic error and so lost a mark. Both methods involved the use of a square root and this is where less able candidates struggled and again lost marks. Also less able candidates struggled to recognise that it was electrical energy being converted to kinetic energy. Where candidates did not score marks in (a), they generally were able to in (b) by using the show that value to calculate the de Broglie wavelength.

$u = 0\,v$. $v = 700\,v$. $q = -1.60\times10^{-19}$ $m_e = 9.11\times10^{-31}$ kg.

$p = mv$ ~~E=ma~~ $E = \frac{1}{2}qV$

~~$= 9.11\times10^{-31}\times$~~ $= \frac{1}{2}\times 1.60\times10^{-19}\times 700 = 5.6\times10^{-17}$

$E_k = \frac{p^2}{2m}$ $\therefore\ p^2 = 1.02032\times10^{-46}$

$p = 1.010108\ldots\times10^{-27}$ Ns

~~1~~ $\times10^{-23}$ Ns

(b) Calculate the wavelength associated with this electron.

(2)

$\lambda = \frac{h}{p} = \frac{6.63\times10^{-34}}{1\times10^{-23}} = 6.63\times10^{-11}$ m

Wavelength = 6.63×10^{-11} m

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Examiner Comments

This candidate has forgotten the electron volt conversion and so has decided to use the energy on a capacitor equation. This happened several times and is an example of candidates using any equation without thinking of the physics.

AS work can be examined on this paper and the electronvolt to joule conversion is one that often appears on this paper.

(3)

$V = \frac{W}{Q}$

$E = \frac{p^2}{2m} = VQ$

$p = \sqrt{V \times Q \times 2 \times m}$

$p = \sqrt{(700) \times (1.6 \times 10^{-19}) \times 2 \times (9.11 \times 10^{-31})}$

$p = 1.43 \times 10^{-23}$ Ns

(b) Calculate the wavelength associated with this electron.

(2)

$\lambda = h/p$

$\lambda = 6.63 \times 10^{-34} / 1.43 \times 10^{-23}$

$\lambda = 46.4$ nm

Wavelength = 46.4nm

ResultsPlus

Examiner Comments

A model answer, by the shortest method, that scores all 5 marks. It is also well presented and easy to follow.

$V \times q$

$E_k = eV = 1.12 \times 10^{-16}$ J

$= \frac{1}{2}mv^2$

$mv^2 = 2.24 \times 10^{-16}$

$v^2 = \frac{2.24 \times 10^{-16}}{9.11 \times 10^{-31}} = 2.46 \times 10^{14}$

$v = \sqrt{2.46 \times 10^{14}} = 15684387.14$

$p = mv = 9.11 \times 10^{-31} \times 15684387.14$

$p = 1.43 \times 10^{-23}$ Ns

$\approx 1 \times 10^{-23}$ Ns

(b) Calculate the wavelength associated with this electron.

(2)

$\lambda = \frac{h}{p} = \frac{6.63 \times 10^{-34}}{1.43 \times 10^{-23}} = 4.63 \times 10^{-11}$ m

Wavelength = 4.63×10^{-11} m

ResultsPlus
Examiner Comments

This candidate also scores all 5 marks but by the extra step method. Compare it to the previous example to see how much more has to be done this way. Apart from taking longer, there is a more chance of making an arithmetic error and so lose marks.

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Examiner Tip

Think before you start a calculation. Are you doing it by the simplest method?

Question 13 (c)

Only 25% of the candidates scored this mark. Many who understood that the electrons were diffracted by the atoms did not compare the wavelength with the atomic spacing. Many thought that the electrons have to be the same size as the atoms or the wavelengths of the electrons and atoms were the same. We never saw that the wavelength was the same size as the nucleus. It was nice to see, although not often, 'the wavelength of the electron is similar to the spacing between nuclei'.

(1)

Because the wavelength is similar to the ~~size of~~ gap between ~~a~~ nuclei so maximum diffraction would occur.

(Total for Question 13 = 6 marks)

$(1.6\times10^{-19})(700) =$

ResultsPlus
Examiner Comments

This is an example of a good response.

Question 14 (a)

Another 1 mark question part that was not well answered. The candidates are to identify that an electron is removed/added from an atom/molecule/particle. Only 36% of candidates scored the mark.

A change in the charge of a particle from ~~po~~ neutral to positive or negative

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Examiner Comments

This candidate does at least refer to a particle but there is no mention of electrons.

Causes the loss of electron or gain of electrons of a material making it unstable (1)

ResultsPlus
Examiner Comments

This candidate does refer to an electron but refers to a material so does not get the mark.

Question 14 (b)

We were looking for Fleming's left hand rule and nothing more as it was only 1 mark. 64% managed to get this correct.

Question 14 (c)

This question was about what the candidate could deduce from the diagram and so answers about matter antimatter without referring to the diagram did not score many marks. Most candidates were able to identify that the photon was neutral because it did not leave a trail and many commented on the paths having matching radii so equal momentum. Candidates who identified that the particle produced had opposite charges due to conservation of momentum did better than those who made the point by referring to the curving in opposite directions, A common answer was to say that the particles moved in opposite directions which is wrong. Initially they are in the same direction and their relative orientation is continually changing. Candidates needed to refer to the curving or spiralling in opposite directions in order to get the mark. Hardly any candidates observed that since the particles initially move to the right, that in order to conserve momentum the photon must have entered from the left. Candidates were unable to separate the fact that because of the magnetic force, the momentum of the particles continuously changes from the condition of conservation of momentum at the moment of the event. Many candidates argued that the initial momentum was zero so the photon was stationary. This question part provided excellent discrimination with the full range of marks being awarded and 2 and 3 being the most common marks.

- The photon must have a neutral ~~nega~~ electric charge because it doesn't produce a track
- The two particles must have opposite charge because they curve in opposite directions, and also because charge is conserved in the interaction.
- The two particles must have the same momentum because their radius of curvature is the same and $r = \frac{p^2}{Bq}$. This is also true because momentum is conserved in the interactions
- ~~The two particles~~ mass / energy is conserved

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Examiner Comments

This candidate scored 4 marks, neutral photon, opposite charges equal radii and same momentum. There is no identification of which is positive/negative or any mention of conservation of momentum. The use of bullet points makes this easy to read and mark. It also helps the candidate to finish one point before starting the next.

~~They are oppositely charged~~ the photon has no charge as no lines / tracks can be seen before point Z. The two particles produced are of opposite charge as the rotate in different directions from the magnetic field. The top particle experiences a force ~~to the left/left~~ at 90° to the left of its motion, and using flemings left hand rule this shows it is positively charged. The bottom particle experiences an opposite force to the right of it direction of motion and so is negatively charged. Both particles have the same radius of motion so using $r = \frac{p}{BQ}$ we can tell they have equal magnitude of mass and momentum. The photon was moving from left to right as both particles produced move the the right initially and momentum must be conserved in a decay.

ResultsPlus
Examiner Comments

This is an example of a response which scored all 5 marks.

Question 15 (a) (i)

The most common mark was 1 followed by 0 then 2. Some candidates did not realise that they were meant to be critical about the actual table of results and not commenting on the relationship that the results gave. There were three possible answers of which any two would score the marks. The most common and incorrect answer was to say that the radius should have been measured in metres not centimetres. How many of them when doing practicals record distances in metres! Quite a few candidates identified the inconsistency in the number of significant figures and some did refer to there being no repeats. While many said (without credit) 'have smaller intervals', it was extremely rare to see any reference to the need for more readings where there was a significant change in the voltage.

(2)

• Not measured ~~in~~ in metres, centimetres is used which is not a Standard index unit
- Not recorded to a constant number of significant figures, changes from 2 to 3
• No repeat readings

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Examiner Comments

This scored 2 marks because the candidate gave three answers. Since we hadn't specified how many comments (although 2 marks is a good indicator) we did not take the first two answers.

As the distance increases the voltage should go down by ~~the~~ the inverse square law ~~it goes down~~ by

ResultsPlus
Examiner Comments

An often seen answer where the candidate has not understood what is meant by criticise.

Question 15 (a) (ii)

The most commonly awarded mark was 2 given for (a)(ii)(1). Most candidates understood what to do and the majority took two pairs of values and multiplied them to give a constant. Some chose to find the constant with one pair and use that constant with another reading of usually distance to find a value of voltage and compare it to the value on the table. Both were acceptable methods. Some candidates forgot to make a comment about the validity of the suggestion and so only scored 1 mark.

(a)(ii)(2) was only 1 mark and required candidates to refer to a straight line graph passing through the origin. Only 14% of candidates included the reference to the origin.

Question 15 (b)

The context of this question part was electromagnetic induction. Just quoting Faraday's law was not sufficient. The question also had information that the reading on the voltmeter was zero so again no mark for just repeating what is in the stem of the question. Candidates' answers needed to be in terms of the question which was about a constant current which produces a constant magnetic field. Candidates who did not refer to the constant current could not score full marks. Most candidates could explain what was needed for the e.m.f. to be induced but most then referred to there being no flux cutting rather than relating the constant current to an unchanging field. For (ii) we were looking for specific actions in the context of the wire and coil so answers about using magnets scored no marks. Many candidates could identify the idea of relative movement between coil and wire and the use of an a.c. supply but the idea of switching the current on or off or using a variable resistor was rarely seen.

faradays law states the induced emf is directly proportional to the rate of change of flax density.
so no emf would be induced.

(ii) State **three** different ways in which an e.m.f. could be induced in this coil.

(3)

flux cutting
rotating the current carrying wire
put a magnet through the coil of wire.

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Examiner Comments

(i) This scores 1 mark for linking the induced e.m.f. to a changing magnetic field but there is no comment about the current for the 2nd mark.

(ii) Flux cutting is not specific enough and no credit for the magnet but this does score 1 mark for rotating the wire.

Think about the context of the question. This question part was about appreciating that a constant current produces a constant magnetic field.

(2)

Faraday's law states that the induced emf is directly proportional to the rate of change in flux linkage. The small coil of wire isn't moving ~~inside~~ relative to the magnetic field of the current carrying wire. So there is no change in flux linkage, so no emf is induced.

(ii) State **three** different ways in which an e.m.f. could be induced in this coil.

(3)

The small coil of wire could be continuously moved relative to the magnetic field of the current carrying wire. The current carrying wire could be moved inside the small coil of wire. Put an alternating current through the current carrying wire.

(Total for Question 15 = 10 marks)

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Examiner Comments

A common wrong answer. The candidate thinks there is no e.m.f. because the coil isn't moving.

The wire carries a constant current ∴ there is no change in magnetic flux, so no EMF is induced and so the reading is zero.

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Examiner Comments

An example that scores 2 marks for (i).

Question 16 (a)

It was very disappointing to see that only 2% of candidates could correctly define electric field strength by referring to a positive charge as well as the force per unit charge. Candidates need to know their definitions. It was not uncommon to see just writing out, from the formula sheet, the three formulae that start E.

The strength of the electric field

$E = F/Q \quad E = \frac{kQ}{r^2} \quad E = \frac{V}{d}$

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Examiner Comments

An example of just rearranging the words and writing down the three equations.

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Examiner Tip

Never give examiners a choice, we won't make the choice for you. So the moment you write down more than one possible answer, you have lost that mark.

the force a charged particle feels

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

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Examiner Comments

When a definition or explanation is asked for, equations can be used but the terms must be defined. This answer did not score any marks.

The force per coulomb of charge experienced by a charged particle in an E field. $E = \frac{F}{q}$

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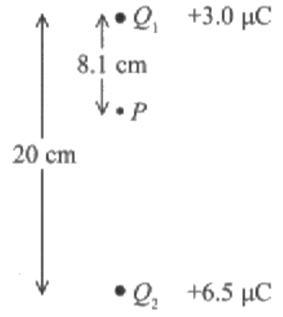
Examiner Comments

A typical answer that scores 1 mark.

Question 16 (b) (i)

Candidates tended to either score 3 or 0 marks for this question. The question asked candidates to show that the electric field strength, at a point, due to two point charges was zero. The majority of those who scored the marks chose to calculate E for each charge at point P and show that they were equal. A number of candidates went wrong because they decided to use Boltzmann's constant for k , presumably because that k appears first in the list of data. They really should know that k is used for two constants. The next group who went wrong were trying to find values for E but just decided to cancel the k so getting a wrong answer. Then there was another group of candidates who didn't realise that they had to do two calculations and since they had two charges, they decided to use Coulomb's force equation. They substituted for both charges and used the distance of 8.1 cm as the separation of the charges. Needless to say this random though common method scored zero. The simplest way to do this calculation which legitimately allows the cancelling of k is to show that the ratio of the two values is 1. This was rarely seen.

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



$E = \frac{V}{d}$

~~$F = EQq$~~

$F = \frac{kQ_1Q_2}{r^2}$

At point P, a distance 8.1 cm from Q_1, the electric field strength is approximately zero.

Demonstrate by calculation that this statement is correct.

(3)

Field strength of $Q_1 = \frac{k \times 3\times10^{-6}}{0.081^2} = 4.11\times10^6$

of $Q_2 = \frac{k \times 6.5\times10^{-6}}{0.119^2} = 4.13\times10^6$

$4.13\times10^6 - 4.11\times10^6 = 0.02 \approx 0$

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Examiner Comments

An example that scores 3 marks.
Candidates did not need to include the unit as in this case but wrong units did mean that a mark was lost.

$F = \frac{k Q_1 Q_2}{r^2}$ $k = 8.99 \times 10^9$

$F = EQ$

$F = \frac{(8.99 \times 10^9)(3 \times 10^{-6})(6.5 \times 10^{-6})}{(20 \times 10^{-2})^2} = 4.38\ N$

$F = EQ$

$E = F/Q = 4.38/3 \times 10^{-6}$

$E = \cancel{1460000.00}\ 1.46 \times 10^6\ NC^{-1}$

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Examiner Comments

An example where the candidate has used the force formula and then divided by one of the charges to get a field. This scored 0.

$$E = \frac{kQ}{r^2} = \frac{(1.38\times10^{-23})(3.0\times10^{-6}\,C)}{(0.0405)^2}$$

$$= 2.52\times10^{-26}\ T$$

$$F = \frac{kQ_1Q_2}{r^2} = \frac{(1.38\times10^{-23})(3.0\times10^{-6}\,C)(6.5\times10^{-6})}{(0.20m)^2}$$

$$F = 6.7275\times10^{-33}\ N$$

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Examiner Comments

A method using Boltzmann's constant. This candidate does correctly find the force between the two charges by using the charge separation of 20 cm but that does not help in determining the field strength at P.

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Examiner Tip

Learn the difference between the two values of k in the list of data and formulae.

Question 16 (b) (ii)

Although we were expecting an answer of zero to this part, we did allow a force calculation based on candidates difference in their E values in the 3rd SF.

Question 16 (b) (iii)

Candidates were asked to explain why energy was needed to move the charge and so their answer needed to say more than 'energy is needed'. They needed to refer to work being done against a repulsive force. A common answer was energy was needed to overcome the electrostatic force without any reference to it being a repulsive force. Candidate also chose to ignore the fact that the force from Q_1 was actually pushing the charge towards the midpoint. The first marking point was for referring to both forces or to the resultant of the forces, this was rarely seen.

Some candidates chose to answer this in terms of equipotential, even though this is not on the specification. Full credit could have been gained but candidates needed to establish the relative values of the equipotential, i.e. that the charge was moving in a direction of increasing energy. This was never done.

Because at P, the force on the charge is zero so in order for it to move, a force needs to be applied (Newton's 1st law). This requires energy: ~~work = forcexdistance~~ Work = Force x distance. Also, pushing it towards Q_2 which has a positive charge as well, there will be a repulsion which energy will be needed to overcome that.

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Examiner Comments

This answer does refer to work and although it only refers to Q_2 it does refer to a repulsive force and so scores 1 mark.

Energy would be needed for this movement because the repulsion from the +6.5μC charge is stronger than the repulsion from the +3.0μC charge. Therefore a resultant force is acting against it and work must be done in order to overcome the force (W=Fas) therefore energy is needed.

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Examiner Comments

One of only 3% of candidates who scored both marks by referring to both forces and work being done.

Moving the two larger positive charges together will require energy to overcome ~~ther~~ the repelling force exerted ~~by~~ on each other.

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The most common answer (72%) of candidates which scored zero.

Question 17 (a)

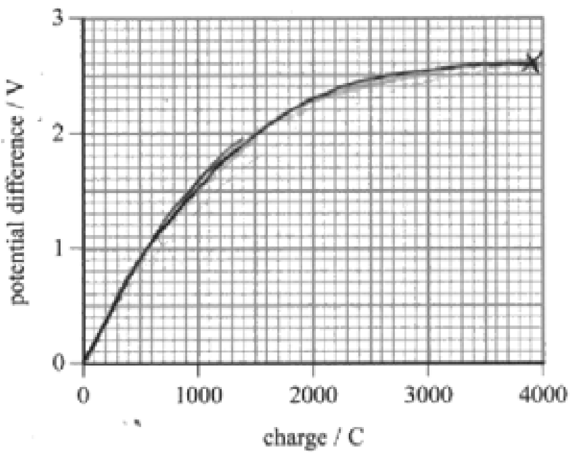
This was a well answered part of the paper with many candidates scoring the full 6 marks. Some lost a mark by drawing the graph as a curve. In (iii) the formula for energy stored on a capacitor is E = QV/2 and candidates had found Q in (i) and were given V so it should have been quite straightforward. However some candidates decided to use E = CV^2/2 and did the usual mistake of using their charge (in C) as their value for C.

$C = \frac{Q}{V}$ $Q = CV$

$Q = 2.6 \times 1500 = 3900$ C

(ii) Complete the graph on the axes below to show how the potential difference varies with charge for this capacitor.

(2)



(iii) Calculate the energy stored in this capacitor when fully charged.

(2)

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

$W = \frac{1}{2}(3900)(2.6)$

Energy = 5070 J

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Examiner Comments

An example of a curved graph instead to the straight line that should have been drawn.

Question 17 (b)

In (i) candidates were expected to identify the graph as an exponential graph and explain that it meant that the current decreased by equal fractions in equal time intervals. Most candidates scored the first mark but not many scored the second one. In (ii) it was very pleasing to see how many candidates were able to calculate the resistance of the circuit. The most commonly awarded mark for the two parts in (b) was 5 with the mark being lost usually through lack of precision in reading from the graph. We identified five different ways that the calculation could be done with either substituting into the formula or finding 37% of I as the most common. Because drawing a tangent to the graph at t=0 is very difficult, candidates who chose that method were allowed a wider range of answers for the final mark. When candidates take two pairs of readings from the graph, they should not use the whole time range. They need to appreciate that because of the nature of an exponential graph it is very difficult to read the current accurately when the capacitor is almost fully discharged. Invariably candidates who used a 2 s time interval ended up with an answer that was out of range and so lost one mark.

(ii) Calculate the resistance of the circuit.

(4)

$I = I_0 e^{-t/RC}$

$\ln I = \ln I_0 \left(-t/RC\right)$

$\ln\left(\frac{I}{I_0}\right) = -t/RC$

$RC = -t/\ln\left(\frac{I}{I_0}\right)$

$RC = -3/\ln\left(\frac{200}{5400}\right)$

$RC = -3/\ln(1/27)$

$RC = 0.91$

$R = \frac{0.91}{1500} = 6.1 \times 10^{-4}\ \Omega$

Resistance = $6.1 \times 10^{-4}\ \Omega$

ResultsPlus
Examiner Comments

One mark for (i) and this candidate has used the 3 s time interval and said that the current is 200 A but that current value applies over the time range of 2.6 to 3.0 s.

time / s

$I = \frac{\Delta Q}{t}$

(i) Describe and explain the shape of the graph.

(2)

The shape of the graph is exponential decay.
As the capacitor discharges, current must decrease
because it is proportional to the charge on the capacitor
(since $I = \frac{\Delta Q}{\Delta t}$).

(ii) Calculate the resistance of the circuit.

(4)

Time constant = RC

$0.37 \times 5400 = 1998$

Time constant = 0.6 s

$0.6 = RC$

$R = \frac{0.6}{1500}$

$R = 4 \times 10^{-4}\ \Omega$

Resistance = $4 \times 10^{-4}\ \Omega$

ResultsPlus
Examiner Comments

This candidate has correctly calculated a current of 1998 A and has drawn horizontal and vertical lines but has read the time axis as 0.6 s instead of 0.8 s.

ResultsPlus
Examiner Tip

Read the graph scale carefully.

The shape of the graph is following exponentially decay (i.e. the current will fall ~~[illegible]~~ by the same fraction of its starting value in a given time). This happen because as the capacitor discharges, ~~the [illegible] become~~ the resistance through the resistor it is discharging through increase also.

(ii) Calculate the resistance of the circuit.

(4)

$I = I_0 e^{-t/RC}$

$\therefore \ln I = \ln I_0 - \frac{t}{RC}$

when $t = 1s$, $I = 1500A$

$\Rightarrow \ln(1500) = \ln(5500) - \frac{1}{1500 \times R}$

$\therefore \frac{1}{1500R} = \ln(5500) - \ln(1500)$

$\therefore 1500R = \frac{1}{\ln(5500) - \ln(1500)}$ $\therefore R = 5.13 \times 10^{-4}\,\Omega$

Resistance = $5.13 \times 10^{-4}\,\Omega$

ResultsPlus

Examiner Comments

An example that scores full marks for both sections.

Question 17 (c)

This is another example of where candidates need to add something extra to what is in the question. The stem gives the information about amount of charge and time to deliver the charge. Candidates needed to combine the idea of charge and time to talk about current or power. Most candidates identified the correct driving conditions but failed to relate them to current or power and so scored 2 of the 3 marks. Some candidates lost a mark because they thought that capacitors were best for acceleration and deceleration. Some candidates were confused and talked about batteries in a conventional engine and how it was charged up while driving. The question clearly stated that it was talking about electric cars and so candidates needed to make sure that they read the question properly.

Going up hills where more power is needed would be more suitable for ultracapacitors. Bursts of acceleration would also be suitable for ultracapacitors as the delivery of the energy would need to be quick Batteries would be more suitable to flat areas where only a steady speed is required as ~~not~~ less energy is needed at this stage of the journey.

(Total for Question 17 = 15 marks)

ResultsPlus
Examiner Comments

An example that does score 3 marks.

- for a batterie the best suited stage of a journey would be when you are driving at a constant velocity
- for a ultracapacitor the best suited stage of a journey would be when you need to accelerate quickly.

ResultsPlus
Examiner Comments

An example of the most common answer scoring 2 marks.

Ultracapacitors would be used for accelerating & decelerating in the journey as it would be much more sensitive. The battery would be used when cruising at a constant velocity.

ResultsPlus
Examiner Comments

Seen quite often, they are thinking about rapid changes.

Question 18 (a)

This also provided excellent discrimination across the mark range with 2 and 3 being the most commonly awarded marks. The mark that was most often missed was the link between electric field and a force on the particles. Candidates must think electric field → force on a charge → acceleration.

Similarly for magnetic field → force on a moving charge → at right angles to motion → produces circular motion. There was a mark for an extra detail but often what was written was not enough to award the mark. A clear statement that the E field reverses every half cycle scored the mark but all too often candidates just wrote that the field had to change so that the particle was always being repelled from one and attracted to the other. This wasn't detailed enough for the mark.

The electric field between the two dees causes the particles to accelerate. The current is alternating so the particles are accelerating both directions. The magnetic field causes the particles to follow a circular path and aims them back towards the electric field between the dees.

ResultsPlus
Examiner Comments

This scores 2 marks, one for electric field and acceleration and one for the circular path.

Electric fields appy a force on the proton. This force causes an acceleration. $a = Eq/m$. The electric field reverses every time the proton enters the other dee. Cause acceleration between the gaps in dee. Magnetic fields provide a force on moving protons. this force causes a curved path. Magnetic fields provide the centripetal force. the resultant force is towards the centre of the circle. The radius of curve is equal to, $r = p/Bq$

ResultsPlus
Examiner Comments

An example that scores 5 marks. The comment about the field reverses every time the particle enters a dee was acceptable.

Question 18 (b)

This was generally well answered with 68% of candidates scoring the full 3 marks. Lots of ways to go wrong, forgetting to square c, dividing by c^2 or multiplying by e and even if you get both of those bits right, there is the Giga hurdle to get over.

(3)

$$\frac{2.5\times10^{-28}\times(3\times10^{8})^{2}}{1.6\times10^{-11}} = 1.4\ \frac{GeV}{c^{2}}$$

ResultsPlus
Examiner Comments

Correct physics but a power of ten error (answer is 0.14 GeV/c^2). This scored 2 marks.

$E=mc^2$

$E = 2.5\times10^{-28}\times(3\times10^{8})^{2}$

$= 2.25\times10^{-11}$ J

$= 1.41\times10^{8}$ eV

$= 0.141$ GeV (3sf)

2.5×10^{-28} kg $= 0.141$ GeV/c^2 (3sf)

Mass = 0.141 GeV/c^2

ResultsPlus
Examiner Comments

An example of a 3 mark answer.

Question 18 (c)

When a question says 'explain' it means that words are needed not calculations. The key factor here was the + sign. To say that the charge is 2/3 the charge of a proton is correct but if candidates chose to answer in terms of an electron they had to write the word positive. Just writing +2/3 was just copying the question and did not convey that the candidates understood that it was of an opposite sign to the electron. Some candidates did a calculation to give a numerical answer. If that was what was wanted, the question would have said determine not explain.

Question 18 (d) (ii)

Candidates found this section difficult and the full 3 marks were rarely awarded. Candidates needed to identify that mass-energy is conserved, that before the interaction the K^- and the proton both had mass (energy) and kinetic energy and that the extra mass comes from the initial kinetic energy. For many candidates $E = mc^2$ is seen as a magic phrase but just quoting it is not enough, an explanation was needed for MP1. Some candidates decided that this was all to do with particles travelling close to the speed of light and others were fixated by the inelasticity of this collision which was an unfortunate distraction. There were also quite a few references to binding energy.

• ~~Energy wass transfered~~ 'left over & binding energy was transfered to mass.
• Energy from surounding was taken is to transfer as mass

ResultsPlus
Examiner Comments

Nothing of merit in this answer.

Some of the kenetic energy of the previous two particles was converted into mass that created the particles produced.

ResultsPlus
Examiner Comments

A correct statement but only worth 1 mark.

$E = mc^2$, so Energy can become additional mass, so ~~energy has~~ energy has been used up.

ResultsPlus

Examiner Comments

This scores 1 mark for the idea of mass energy interchange but there is no mention of kinetic energy which is needed for 2 of the marks.

Mass-energy must be conserved and it is the kinetic energy of the particles before that have caused the increase in mass. The collision ~~er~~ must be inelastic, so energy has been lost but this has been turned into mass to conserve mass-energy ($E = mc^2$).

ResultsPlus

Examiner Comments

An example of an answer that scores 2 marks.

Paper Summary

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

- It is important to answer context based questions in terms of the context and not just quote the relevant bit of physics. There were several question parts where candidates scored well but marks were often lost when candidates were applying their knowledge to a specific context.
- It is important that candidates take note of the command words that are used, for example 'explain' where words are required not calculations.
- Candidates should be familiar with the formula sheet and be aware of where a letter is used for more than one meaning. It is unfortunate that marks are lost because candidates have not learnt specific definitions.
- Learn the difference between the two values of k in the list of data and formulae.

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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