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Examiners' Report
January 2012

GCE Physics 6PH04 01

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Introduction

The paper provided some challenges to candidates. Although most candidates found some parts difficult, all of the marks were awarded to some candidates. Marks were often lost due to lack of detail. This paper contained a number of questions where a result was given and the candidates were asked to justify it. Often the answers given lacked a sufficient number of physics points. Although a candidate might want to repeat what is said in the stem of a question to complete their answer and this is to be encouraged, candidates should realise that just repeating what has been given will not gain marks. There were also a number of questions where it was obvious that candidates had not read the question properly.

Section A

The response to the multiple choice questions was generally good with 5 of the questions having over 70 % correct answers and only 1 with less than 40% correct answers.In order of highest percentage correct they were, Q6 (89%), Q8 (87%), Q4 (84%), Q9 (76%), Q7 (74%), Q10 (50%), Q1 (46%), Q3 (46%), Q5 (43%) and Q2 (25%).

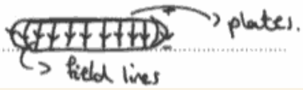
Q2 was a vector diagram and candidates needed to realise that the combined effect of 1 and 2 was the same as the combined effect of 3 and 4, hence C was correct. Q5 required students to realise that in a motor, as soon as the coil begins to turn in a magnetic field, an induced e.m.f. opposes this and has the effect of reducing the current but not to zero. Q3 has a bus going around a bend exerting a force on a passenger towards the centre of the circle.

Question 11 (a)

Many candidates concentrated on the uniform part of the question rather than the field and so consequently scored only one mark. It was disappointing to see how few candidates could accurately describe an electric field as an area/region where a charged particle experiences a force. Some candidates need to realise that the field lines are used to represent the field, but are not themselves the field.

11 (a) Explain what is meant by a uniform electric field. **(2)**

An electric field is a region of space in which a charged particle with experience a force. An uniform electric field is made up of two parallel plates, with a potential difference applied across it. The field lines are equally spaced and parallel and the strength of the field at any point is the same, that's why it's called uniform.



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Examiner Comments

This scores two marks for the region of space where a charged particle experiences a force and the second mark for the field strength being constant.

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Examiner Tip

Be careful not to write too much, this part doesn't ask how to produce a uniform field, that is in the next part, so time is wasted writing about it.

11 (a) Explain what is meant by a uniform electric field. **(2)**

A uniform electric field is a region of space, (a field) ~~in which~~ between oppositely charged electrodes ~~.....~~ across a potential difference. The electric field strength is constant at all points in the field.

ResultsPlus
Examiner Comments

This candidate does start by mentioning a region but fails to talk about the effect on a charged particle. It scores the second mark for the constant electric field strength.

ResultsPlus
Examiner Tip

This scored zero. Strength is not good enough for 'electric field strength' and although a region is mentioned, it should be related to a force. Depending on other forces, the particle may or may not accelerate.

Question 11 (b)

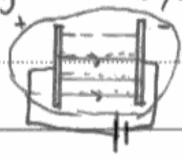
Some candidates having used the parallel plates to answer (a) did not restate it in this part and often just referred to two plates. The question asked how a uniform field could be demonstrated in a laboratory and so there was an expectation of the candidates saying something like 'connect a power pack to two parallel metal plates'. That would have scored 2 marks. A diagram was acceptable for these two marks. Not many candidates scored the third mark possibly because they had never seen this demonstrated.

(b) Describe how a uniform electric field can be demonstrated in a laboratory.

(3)

apparatus needed: Parafin oil, circuit and cell, a bowl, 2 plates and some semolina powder.

- Connecting the two plates to a circuit ie (one positive one negative) dip them in the parafin oil and sprinkle some powder over it, the powder will align itself like bipolar molecules in the direction of the field showing that the field strength is equal.



(Total for Question 11 = 5 marks)

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Examiner Comments

A example that scores three marks. The description of one plate being negative and one positive, is not good enough for the 2nd mark but the circuit diagram scores the marks.

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Examiner Tip

Diagrams are often a very good way of answering a question.

(b) Describe how a uniform electric field can be demonstrated in a laboratory.

(3)

Two metal plates with a potential difference across them. If a negatively charged particle is placed at any point in the field the acceleration towards the positive plate will always be constant.

ResultsPlus
Examiner Comments

This answer lacks detail, no mention of the plates being parallel or of how the potential difference is achieved. Also just referring to a charged particle is insufficient. This scored zero.

(b) Describe how a uniform electric field can be demonstrated in a laboratory.

(3)

~~2 class charged plat~~ 2 parallel plates can ~~fe~~ be connected to a power supply so that they are oppositely charged. A charged ~~object~~ ~~a~~ ~~object~~ object can be placed at any point between the plates

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Examiner Comments

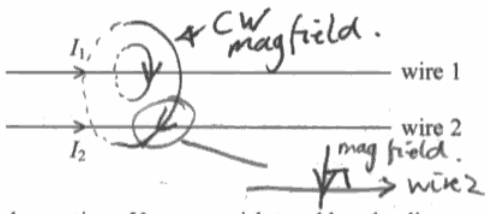
The first sentence scores two marks.

Question 12

This was a context based question where there was a hint to candidates that a current produces a magnetic field and they were told that there is a force of attraction between the two wires when the currents are in the same direction. Because they were told this, there was no mark for candidates who said that the force on wire 2 was upward and the force on wire 1 was a downward. Many answers lacked detail, jumping straight from the wires producing a magnetic field to the force acting on the wires. Five marks means five different physics points are required. Hardly any candidates said that each wire was in the magnetic field produced by the other wire or that a current carrying wire in a magnetic field can experience a force.

***12** In 1820 Hans Oersted did an experiment with an electric current in a wire. He noticed that whenever the current was on, it affected a compass needle lying near the wire.

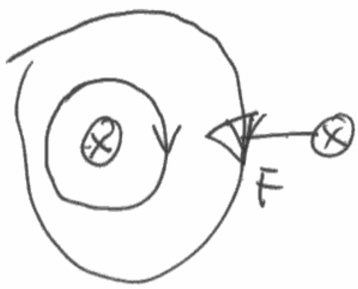
A few years later, André Ampere observed that two parallel wires attract each other if they are carrying current in the same direction.



Explain André Ampere's observation. You may wish to add to the diagram.

(5)

The current in the wires produces ~~a~~ clockwise magnetic fields (as shown for wire 1). This field crosses the second wire at 90°, by Fleming's Left hand rule, this causes a force to be felt on wire 2 in the direction of wire one. The ~~converse~~ same is true, ~~with~~ when considering the mag field induced by wire 2. The force is felt towards the other wire



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Examiner Comments

An example of an answer that scores 4 marks. The phrase 'a clockwise magnetic field' is not enough for the current because it is not related to a current direction but the diagram around wire one and the one below are both good enough for this mark. This candidate makes a clear statement that the field of one wire, crosses the other wire. The only point not awarded is the statement about the conditions necessary for a force.

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Examiner Tip

We accept without labelling the convention that a cross indicates a current into the page and a dot, a current out of the page.

*12 In 1820 Hans Oersted did an experiment with an electric current in a wire. He noticed that whenever the current was on, it affected a compass needle lying near the wire.

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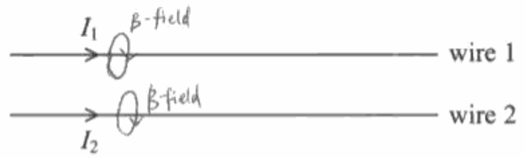

Explain André Ampere's observation. You may wish to add to the diagram.

(5)

By right hand rule, the magnetic field is always perpendicular to the current flow. Thus in Hans Oersted's experiment, the compass is affected when lying near the wire.

B-field on wire 1 : B-field on wire 2 :

As the B-field on the right hand side of wire 1 is direct to the left hand side of B-field on wire 2.

They will attract each other.

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Examiner Comments

This candidate tries to draw the magnetic field around the wire but unfortunately you can't tell if the arrow is going down at the front or the back so this only scored 1 mark for the existence of the magnetic field. In the diagrams below there is no indication of current direction so again the mark for direction is not awarded.

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Examiner Tip

Make sure your diagrams are clear. A small gap can indicate where the field goes behind the wire.

*12 In 1820 Hans Oersted did an experiment with an electric current in a wire. He noticed that whenever the current was on, it affected a compass needle lying near the wire.

A few years later, André Ampere observed that two parallel wires attract each other if they are carrying current in the same direction.

Explain André Ampere's observation. You may wish to add to the diagram.

(5)

~~The electric current what~~ The fact that the compass needle was affected by the electric current shows that there must be a magnetic field, ~~Any metal~~ as any metal object placed in that region of changing magnetic field will induce an emf. This induced emf will cause a current to flow in the wires. The magnetic field must ~~be show~~ act in opposite directions as if this is true, then according to Fleming's left hand rule, the wires will feel a force towards each other. ~~The wires~~ The electric current must cause the wires to become oppositely charged as opposite charges attract.

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Examiner Comments

Unfortunately some candidates tried to use the wrong physics and answers like this about an induced e.m.f. were not uncommon.

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Examiner Tip

Think about the situation before you start writing. For an e.m.f. to be induced you need either a changing magnetic field or relative movement neither of which are in this question.

Question 13

This question was generally answered very well with over 50% of candidates scoring the full 5 marks. A number of candidates made casual slips in their wording with the use of reflected, bounced or rebounded instead of deflected. For the first mark some candidates omitted the word straight and quite a few used free instead of empty for the 4th mark. Rutherford's experiment established that the nucleus was charged and not that it was positively charged. Since we now know that it is positively charged, we do not penalise those candidates who say that, however those that merely say the nucleus is positive i.e. miss out the word charged, do not get the mark.

*13 At the beginning of the last century, experiments were performed using alpha particles and gold foil. The alpha particles were directed at the gold foil and a detector was used to see if and where they were scattered.

Summarise the results from these experiments and the conclusions that were drawn from them.

(5)

Most of the alpha particles went straight through the gold foil, their path was undisturbed. Some alpha particles were deflected by angles ranging ~~for~~ from -90° to 90°. The greater the magnitude of the angle by which the α-particles were deflected, the fewer particles were deflected. Also, it was observed that some (very few) α-particles were actually reflected by the gold foil.

From this experiment, it was concluded that most of the gold atoms are empty space. It was also concluded that atoms have a positive nucleus at the centre surrounded by electrons and that the positive nucleus occupied a very small fraction of the atom.

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Examiner Comments

An example of a very good answer. This does not mention anything about the mass of the atom but because this question was a maximum five out of six marking points, this answer scored five marks.

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Examiner Tip

Remember when there is a * in front of a question or a question part, the quality of your written communication will be assessed. This answer is very well expressed and grammatically correct.

*13 At the beginning of the last century, experiments were performed using alpha particles and gold foil. The alpha particles were directed at the gold foil and a detector was used to see if and where they were scattered.

Summarise the results from these experiments and the conclusions that were drawn from them.

(5)

Most of alpha particles passed straight through the gold foil un-deviated. a few alpha particles deflected and very few alpha particles deflected & bounced off with an angle > 90°. This can be inferred that most of the atom is empty space. Since alpha is positively charged and deflected when alpha is near nucleus, the nucleus has a positive charge. very tiny proportion of alpha deflected through large angle means that mass and charge is concentrated in the nucleus. The nucleus has a massive mass.

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Examiner Comments

Another example of a full mark answer.

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Examiner Tip

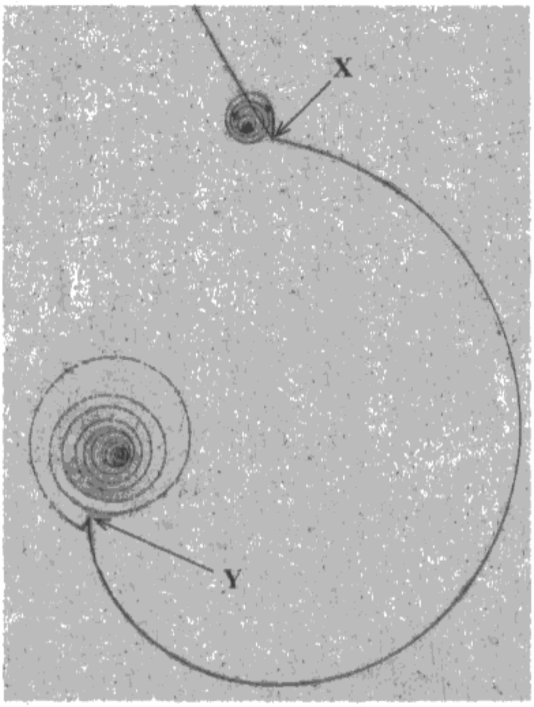
This is not quite as well expressed as the previous answer but it is still satisfactory for the quality of written communication.

Question 14 (a)

This question as a whole was a good discriminator. All candidates were able to access some of the marks.

In (a) over 75% of the candidates were able to state that the magnetic field caused the particle to move in a circular path but it was only 25% of candidates who went on to say what could then be measured. The majority of those went for charge identification with very few saying anything about momentum/energy/velocity. A common answer with weaker candidates was to say that the magnetic field was necessary to force the particles to move through the detector.

14 The photograph shows tracks in a particle detector.



(a) Explain the role of a magnetic field in a particle detector.

(2)

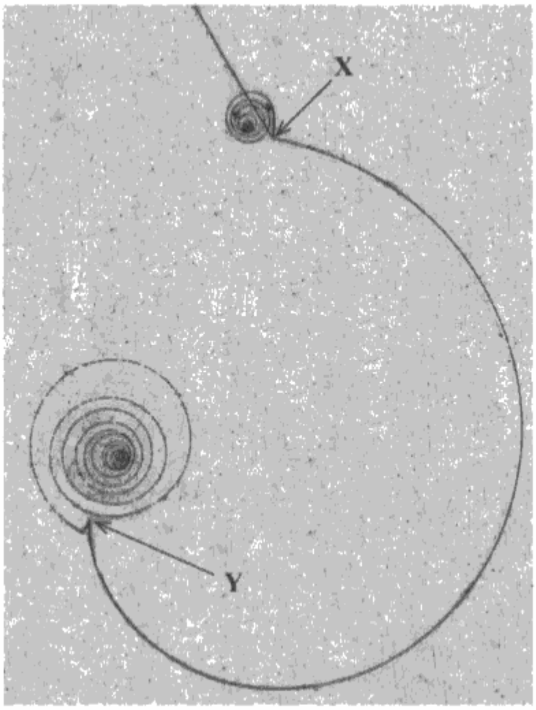
The magnetic field is required to determine ~~the direction~~ the mass/momentum and charge on a particle, by causing charged particles to be deflected in an arc. The direction and radius of the arc can be used to determine momentum and charge

(b) Explain how you can tell that track XY was produced by a particle moving from

ResultsPlus
Examiner Comments

A two mark answer.

14 The photograph shows tracks in a particle detector.



(a) Explain the role of a magnetic field in a particle detector.

(2)

The magnetic field allows us to determine the charge of the particle and its speed to some extent.

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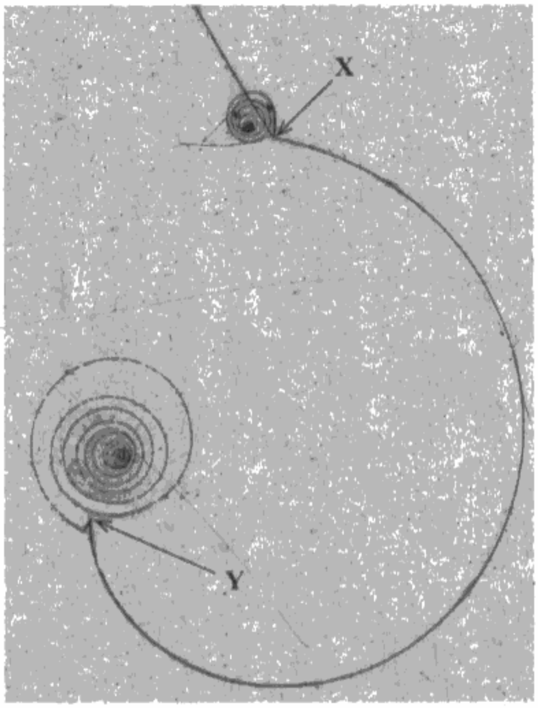
Examiner Comments

An unusual answer that identifies the use but not the circular path.

14 The photograph shows tracks in a particle detector.



$r = \frac{p}{Bq}$

(a) Explain the role of a magnetic field in a particle detector.

(2)

It provides a force on the moving charge. This produces circular motion and a centripetal acceleration.

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Examiner Comments

The most common type of answer that was seen, scoring 1 mark.

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Examiner Tip

Only one piece of physics has been given but the question has two marks.

Question 14 (b)

The majority of candidates who realised that the radius of curvature decreased from X to Y went on to talk about loss of speed/momentum/energy and so scored 2 marks. It was unusual to award only 1 mark. Quite a few candidates did not read the question and only considered what was happening between X and Y and tried to use what was happening at the spirals to justify their answer. These candidates usually scored zero.

(b) Explain how you can tell that track XY was produced by a particle moving from X to Y rather than from Y to X.

(2)

The radius becomes smaller towards 'Y' as the particle loses momentum this is due to ionisation within the bubble chamber.

ResultsPlus
Examiner Comments

A perfect 2 mark answer.

(b) Explain how you can tell that track XY was produced by a particle moving from X to Y rather than from Y to X.

(2)

At X the spiral shows that the particle was speeding up/accelerating. That is why a large circular motion with increasing radius is seen. At Y, acceleration is decreasing.

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Examiner Comments

An example of an answer that scores 0.

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Examiner Tip

Read the question, you only need to look at the track XY and nothing else.

Question 14 (c)

(c) Since the path of the particle is a curve, the force must be to the centre of the circle i.e. force and direction of motion are in the plane of the paper, the expected answers for the direction of the magnetic field were 'out of the page' (correct) and 'into the page' (incorrect). 60% got this right but that doesn't mean to say that the other 40% said 'into the page'. There were lots of random answers such as 'left to right' and ' north to south'. Unfortunately quite a few candidates said upwards which we could not credit because it might have meant towards the top of the page.

(c) The particle that produced track XY was a π^+. Deduce the direction of the magnetic field in the photograph.

(1)

from right to left

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Examiner Comments

An unexpected answer.

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Examiner Tip

Direction of motion (current), force and magnetic field are the three mutually perpendicular components of Fleming's left hand rule. It is important to remember this.

(c) The particle that produced track XY was a π^+. Deduce the direction of the magnetic field in the photograph.

(1)

The magnetic field is in the verticle direction.

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Examiner Comments

An example of an ambiguous answer. Vertical could mean out of the page but it also could mean towards the top of the page. Students should be encouraged to use the phrase into/out of the page.

Question 14 (d) (i)

Generally well answered, 46% of candidates scored 1 mark and another 44% scored two marks. For the conservation of charge mark, something more than 'it is neutral because charge has to be conserved' was needed. There had to be some mention of the actual particles involved in this decay.

(d) At Y, the π^+ decayed into a positively charged muon (μ^+) and a muon neutrino. The μ^+ has a very short range before decaying into various particles, including a positron which produced the final spiral.

(i) Give **two** reasons why you can deduce that the muon neutrino is neutral.

(2)

1 ~~There is only~~ Particle dector can only detect charged particles ~~One~~ In the photograph, there is only one path for the positron. No path for muon neutrino.

2 Due to conservation of charge. π^+ is positive charged.

$\pi^+ \rightarrow \mu^+ + \nu_\mu$ μ^+ is positive charged, therefore muon neutrino must be neutral.

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Examiner Comments

An example of a two mark answer.

(d) At Y, the π^+ decayed into a positively charged muon (μ^+) and a muon neutrino. The μ^+ has a very short range before decaying into various particles, including a positron which produced the final spiral.

(i) Give **two** reasons why you can deduce that the muon neutrino is neutral.

(2)

1 It left no tracks ~~in~~ so did not ionise anything

2 Conserves charge by being neutral

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Examiner Comments

This scores 1 mark for the no track comment.

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Examiner Tip

Whenever there is a specific decay, you must always refer to the particles and their charges to justify conservation of charge.

(d) At Y, the π^+ decayed into a positively charged muon (μ^+) and a muon neutrino. The μ^+ has a very short range before decaying into various particles, including a positron, e^+ which produced the final spiral.

(i) Give **two** reasons why you can deduce that the muon neutrino is neutral.

(2)

1 $\pi^+ \rightarrow \mu^+ + \nu_\mu$ Charge is conserved. The charge of the π^+ before decay is +1. Thus, the total charge after decay is +1 as well. $+1 = +1 + \nu_\mu$. $\nu_\mu = 0$ Charge of muon neutrino is zero, because μ^+ has a charge of +1.

2 The decay of μ^+ produces a positively charged positron. Charge is conserved. $\pi^+ \rightarrow e^+ + \nu_\mu$ $+1 \rightarrow +1 + \nu_\mu$ $\nu_\mu = 0$ ν_μ is neutral.

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Examiner Comments

An excellent answer for conservation of charge unfortunately it is repeated twice but only scores 1 mark.

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Examiner Tip

There is no point repeating something just to fill a space. If you can't think of an answer, it is better to leave it blank rather than waste time repeating yourself.

Question 14 (d) (ii)

The key to this question was noticing the discontinuity in the visible path at Y. Quite a few of those who did notice this went on to discuss conservation of momentum and score the full three marks. Unfortunately 40% of candidates scored zero on this part. Some candidates worked out by a process of elimination that this must be to do with momentum having dealt with charge and no track in (i) but couldn't identify the relevant feature of the picture. These candidates did score one mark.

(ii) Explain the evidence from the photograph for the production of the muon neutrino at Y.

(3)

The track changes direction suddenly, indicating a decay. There is only one track continuing after however, indicating that the other particle that must have been produced is neutral.

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Examiner Comments

A few candidates did notice the change in direction of the path but couldn't relate it to momentum. This scored 1 mark.

(ii) Explain the evidence from the photograph for the production of the muon neutrino at Y.

(3)

- There is only one track
- The one track is going in the opposite direction of the previous track (before the π^+ decayed) which means another particle ~~mustive~~ must be present to conserve momentum.
- ~~The~~

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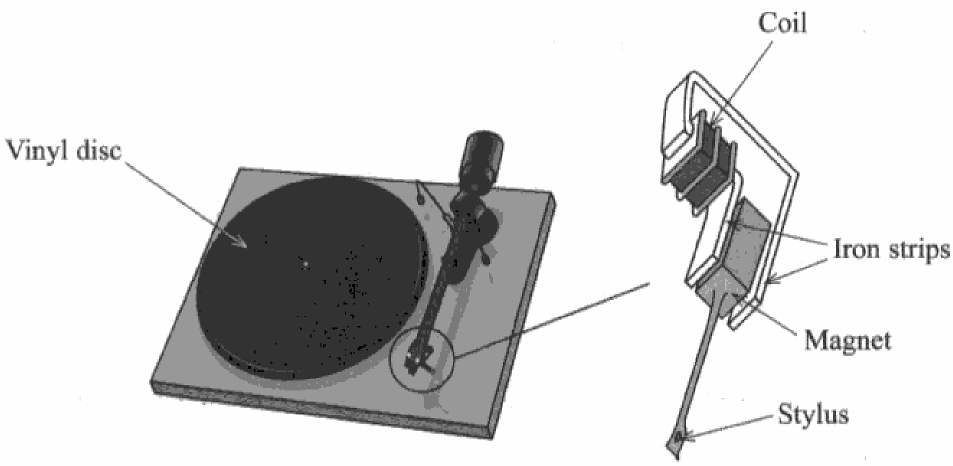
A 3 mark answer. Succinct and accurate.

Question 15 (a)

Virtually all of the candidates recognised this question as an example of electromagnetic induction but the most common mark gained was 2, for the idea of the magnet moving and an e.m.f. being induced. At this level, on an A2 paper , there is an expectation that candidates will use the phrase magnetic flux, however the most commonly used phrase was either magnetic field or just flux. In this question, the magnet is moving relative to the coil and so it is inappropriate to refer to the coil cutting the flux/field. There was a significant number of candidates who were unable to identify what was causing the changes in the magnetic flux with some attributing it to the stylus itself.

15 A vinyl disc is used to store music. When the disc is played, a stylus (needle) moves along in a groove in the disc. The disc rotates and bumps in the groove cause the stylus to vibrate.



The stylus is attached to a small magnet which is near to a coil of wire. When the stylus vibrates, there is a potential difference across the terminals of the coil.

(a) Explain the origin of this potential difference.

(4)

$\mathcal{E} = \frac{-d(N\phi)}{dt}$ As the magnet vibrates, ~~the~~ the coil cuts the magnetic flux lines. This induces an Emf into the coil. The larger ~~the~~ and more frequent the vibrations, the more Emf is induced due to the coil

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Examiner Comments

An example of an answer that scores 3 marks. There is a reference to magnetic flux but this candidate says that the coil is cutting the flux.

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Examiner Tip

A perfect answer would be:

'As the magnet moves, there is a change in the magnetic flux through the coil which induces an e.m.f.

Question 15 (b) (i)

This was a well answered calculation with 60% of candidates scoring 2 marks. For the final mark in any calculation, the calculation must be completed i.e. an answer left as a fraction or including pi will not score this mark. When errors were made, it was usually candidates using T as f or f as T and getting 11.4 radians per second and there were quite a few unit errors with m s^{-1}being used.

Question 15 (b) (ii)

This was generally poorly answered with many candidates scoring 0. It is appreciated that the understanding of what was meant by the encoded bumps was difficult and so the mark scheme focused on the reason for this, i.e. the fact that the tangential speed nearer the centre of the record was less than at the outside. Candidates who realised this and quoted v = rω often scored quite well. Some candidates who used the equation, failed to say that ω remained constant. However, for a lot of candidates there was confusion as to what was going up/down in this situation and often candidates wrote down contradictory statements. There was also some confusion over the use of the word compression, as some candidates took this to mean a reference to a force on the groove and so tried incorrectly, to answer this in terms of centripetal forces.

(ii) As the stylus moves towards the centre of the LP the encoded bumps must be fitted into a shorter length of groove.

Explain why the encoding of bumps in the groove becomes more compressed as the stylus moves towards the centre.

(3)

Since the radius is smaller and ω is constant, the tangential velocity of the stylus ($v = \omega r$) becomes lower near the centre. This means that the same 10s of song must now be fitted into a smaller distance if it is to still last 10s.

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A model answer that scores 3 marks.

(ii) As the stylus moves towards the centre of the LP the encoded bumps must be fitted into a shorter length of groove.

Explain why the encoding of bumps in the groove becomes more compressed as the stylus moves towards the centre.

(3)

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

when it moves towards the centre,

the radius become smaller.

∴ F will become larger,

it will become more compressed.

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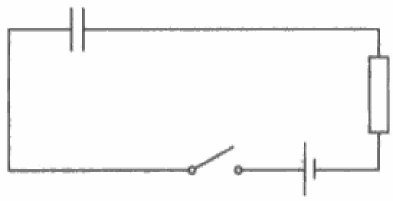
Examiner Comments

An example of a candidate who misinterpreted the word compressed.

Question 16 (a)

This was generally well answered. (a)(i) was a straight forward question about a capacitor charging and the movement of charge around the circuit. There was quite a bit of confusion with (ii) where again candidates did not read the question properly and assumed that the question was asking about the capacitor discharging and its potential difference falling to zero. For those candidates who did read the question properly, most of them scored only 1 mark. This is another example of the candidates being told what happens and so there is no mark for just repeating what is given in the question. Candidates need to realise that the capacitor was in series with a resistor and so they needed to either specify that the current through the resistor was zero or do a sum of p.d.s around the circuit.

16 The diagram shows a circuit that includes a capacitor.



(a) (i) Explain what happens to the capacitor when the switch is closed.

(2)

When the switch is closed, the electrons build up on the Capacitor's side which is connected to the negative terminal of the battery. The Capacitor will then charge until it's EMF is equal to that of the power supply.

(ii) The potential difference (p.d.) across the resistor rises to a maximum as the switch is closed.

Explain why this p.d. subsequently decreases to zero.

(2)

Once the capacitor is charged fully, ~~the~~ no more electrons can continue to go around the circuit, therefore ~~the~~ as $V=IR$, and the current decreases to 0. The pd will subsequently also go to 0.

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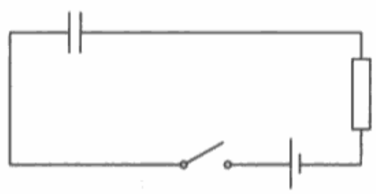
Examiner Comments

This scores 1 mark for (i) because the removal of electrons from the positive plate is removed.

(ii) having established that the charged capacitor stops the movement of electrons, the use of $V = IR$ shows that the candidate is referring to the resistor and this scored both marks.

16 The diagram shows a circuit that includes a capacitor.



(a) (i) Explain what happens to the capacitor when the switch is closed.

(2)

the capacitor will charge up until its potential difference matches that of the rest of the circuit.

(ii) The potential difference (p.d.) across the resistor rises to a maximum as the switch is closed.

Explain why this p.d. subsequently decreases to zero.

(2)

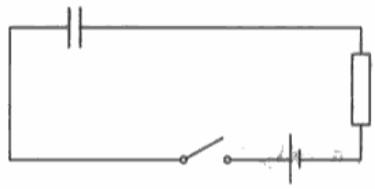
because the capacitor reaches fully charged and has the same potential difference as the battery/power supply. therefore the p.d. across the resistor is 0 as it is equal both sides.

ResultsPlus
Examiner Comments

This scores 1 mark only for the capacitor charging in (i)

Also 1 mark for (ii) since it doesn't say that $pd_{supply} = pd_{capacitor} + pd_{resistor}$

16 The diagram shows a circuit that includes a capacitor.



(a) (i) Explain what happens to the capacitor when the switch is closed.

(2)

The capacitor charges : positive charge builds up on one plate, negative charge on the other. There is a potential difference between the two plates.

(ii) The potential difference (p.d.) across the resistor rises to a maximum as the switch is closed.

Explain why this p.d. subsequently decreases to zero.

(2)

The capacitor charges so that the potential difference between the two plates is the same as the potential difference across the cell. This means there is no p.d. between one capacitor plate and one side of the cell : meaning no p.d. across the resistor. They are connected in series, $V_1 + V_2 = V_{cell}$

ResultsPlus

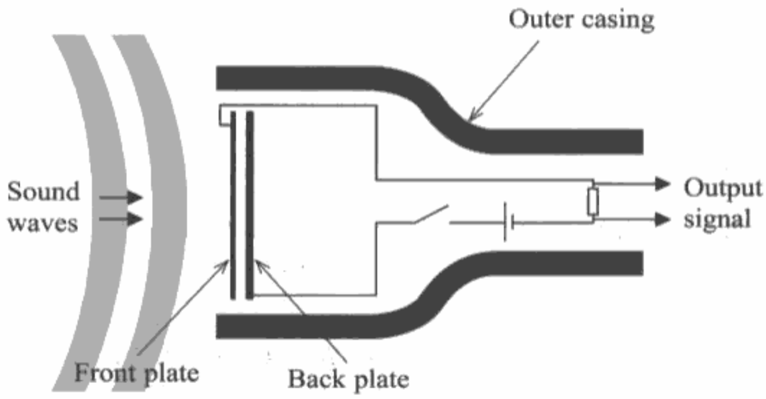
Examiner Comments

An example of an answer that scores all four marks.

Question 16 (b)

This context question that was very poorly answered. As soon as a candidate sees something about capacitance changing, they should find a suitable equation, in this case $C = Q/V$. Candidates weren't expected to know if a change in capacitance would lead to a change in V or Q so there were two alternative mark schemes allowing for either choice. Too often we saw phrases such as 'changing the capacitance will change the charge' without specifying exactly what changes occur. Just quoting the equation and giving a specific change in capacitance linked to a correct change in V or Q would have scored two marks. The next problem was that the majority of students chose to ignore the resistor and assumed that the output signal was the p.d. across the capacitor. A large number of students made no attempt to use an equation and just basically repeated what was in the question. Marks were awarded for accurate points of physics even if they did not lead to the fully correct answer.

*(b) One type of microphone uses a capacitor. The capacitor consists of a flexible front plate (diaphragm) and a fixed back plate. The output signal is the potential difference across the resistor.



The sound waves cause the flexible front plate to vibrate and change the capacitance. Moving the plates closer together increases the capacitance. Moving the plates further apart decreases the capacitance.

Explain how the sound wave produces an alternating output signal.

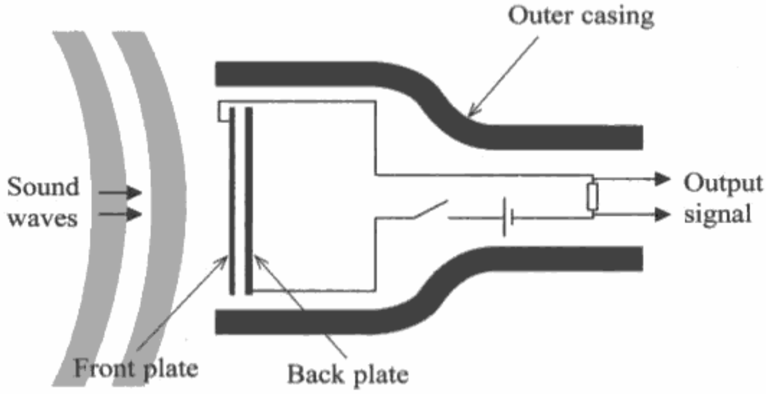
(4)

When the plates are closer together because of the sound waves, the capacitance is greater. $Q = CV$. The ~~capacitor~~ charge stored by the capacitor is constant. When c increases, the p.d across the capacitor decreases. Since the total potential difference across the capacitor and the resistor (output component) is constant, the p.d across the resistor is increases. $V = V_R + V_C$. When the plates are further apart, capacitance decreases. $Q = CV$. p.d across the capacitor (V_C) increases. Thus, V_R decreases. Therefore, the output signal is altered by having alternating potential difference across the resistor.

ResultsPlus
Examiner Comments

A model 4 mark answer.

*(b) One type of microphone uses a capacitor. The capacitor consists of a flexible front plate (diaphragm) and a fixed back plate. The output signal is the potential difference across the resistor.



The sound waves cause the flexible front plate to vibrate and change the capacitance. Moving the plates closer together increases the capacitance. Moving the plates further apart decreases the capacitance.

Explain how the sound wave produces an alternating output signal.

(4)

The sound waves will cause the plates to vibrate, so when the plates are ~~close~~ closer together the capacitance is greater so more charge can be stored which will produce a particular output ~~Sss~~ signal which may be longer and slower but ultimately more powerful. When the sound waves cause the plates to move apart then the smaller capacitance will cause a different output signal which may be faster and shorter and less loud or powerful as a smaller capacitance will mean ~~less~~ less discharging and charging time and so the output signal will be alternated as a larger capacitance can ~~hold more~~ store more charge so will have a greater ~~dis~~ discharging and charging time.

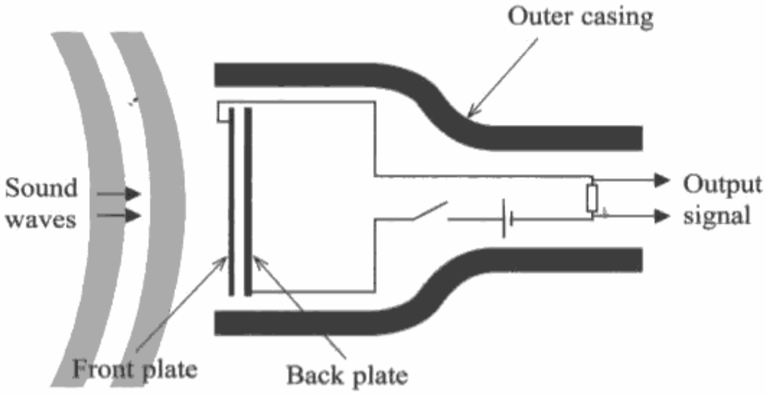
ResultsPlus
Examiner Comments

Scores 1 mark for the link to increases capacitance meaning increased charge.

ResultsPlus
Examiner Tip

Always quote an appropriate equation, just quoting the equation in a context based question will often score 1 mark.

*(b) One type of microphone uses a capacitor. The capacitor consists of a flexible front plate (diaphragm) and a fixed back plate. The output signal is the potential difference across the resistor.



The sound waves cause the flexible front plate to vibrate and change the capacitance. Moving the plates closer together increases the capacitance. Moving the plates further apart decreases the capacitance.

Explain how the sound wave produces an alternating output signal.

(4)

Sound waves are longitudinal so are a set of compressions & rarefractions. These will cause the front plate to move, changing the capacitance. If the capacitance changes, so will the charge flowing through the circuit, it will fluctuate. As the out put signal is connected to the capacitor, and its alternating capacitance (due to recieving alternating sound waves), the output voltage will be alternating, as it is directly affected by the capacitance, as $Q=CV$ so $V=\frac{Q}{C}$, if the capacitance is changing so will the voltage (p.d.)

ResultsPlus
Examiner Comments

An example where the equation is quoted but the actual change in voltage is not specified. This scored 1 mark.

ResultsPlus
Examiner Tip

Quote an equation and then make a specific point about how two of the variables will alter e.g. if charge is constant, as capacitance increases, potential difference will decrease.

Question 16 (c)

The fact that actual values of resistance and capacitance were given in this part was an indication that a calculation was required and quite a few candidates did attempt to find the time constant for these values. There was a varying degree of success since some candidates weren't sure about the conversion of pico. Some candidates then found a frequency for this time constant rather than finding the time period for the wave under consideration. However three marks were still possible for this method. 50% of candidates scored 0 for this section because they tried to answer the question without the back up of numerical values.

(c) A microphone has a capacitor of capacitance 500 pF and resistor of resistance 10 MΩ.

Explain why these values are suitable even for sounds of the lowest audible frequency of about 20 Hz.

(4)

$\tau = RC$ time constant = 5ms

at 20Hz the 'diaphragm' would be vibrating at 20 times a second. $T = \frac{1}{f}$. So the time period would be 50ms this is 10 times bigger than the time constant for the microphone which allows the capacitor to fully charge ~~and~~ or discharge before the next sound wave comes in, therefore these values are suitable for hearing frequencies at 20Hz.

ResultsPlus

Examiner Comments

An example of a 4 mark answer.

(c) A microphone has a capacitor of capacitance 500 pF and resistor of resistance 10 MΩ.

10 000 000   0.0000000 00000 10^{-12} 10^6

Explain why these values are suitable even for sounds of the lowest audible frequency of about 20 Hz.

(4)

$f = \frac{1}{T}$ $C = \frac{Q}{V}$ $V = IR$

$\frac{Q}{C} = IR$

$Q = It$ $\frac{Q}{I} = CR$

$\frac{It}{I} = 500 \times 10^{-12} \times 10 \times 10^{6}$

$t = 5 \times 10^{-3}$

$f = \frac{1}{5 \times 10^{-3}}$

$f = 200$ Hz

ResultsPlus
Examiner Comments

The candidate has omitted a unit of t but since this was an interim step, we assume it is seconds and so this candidate scores 3 marks.

(c) A microphone has a capacitor of capacitance 500 pF and resistor of resistance 10 MΩ.

Explain why these values are suitable even for sounds of the lowest audible frequency of about 20 Hz.

(4)

~~f/R/~~ The capacitance 500pF is a very small number therefore it does not take that long to charge up and only requires a small amount of sound waves. The potential difference between the ~~pos~~ resistor will be very large. This means that the output signal is very large.

ResultsPlus
Examiner Comments

This is typical of many answers where there is no attempt at a numerical analysis.

ResultsPlus
Examiner Tip

If numerical values are given, try to use them.

Question 17 (a)

This question in total was about the production of anti-hydrogen, it appeared that many candidates felt annihilation was a good answer to give whereas in reality it was never a required answer.(a) Many candidates had leant the mantra that an antiparticle has the same mass as its particle but opposite for other properties. Candidates were required to apply that principle to a specific pair of atoms and therefore needed to realise that they were not dealing with single particles. They were expected to realise that both the hydrogen atom and the anti-hydrogen atom are neutral. Candidates who correctly identified the charge of all four particles involved without necessarily saying that the atoms were neutral were given the mark.

17 Anti-hydrogen atoms have been created at CERN. An anti-hydrogen atom consists of an anti-proton and a positron.

(a) Compare the properties of an anti-hydrogen atom with a hydrogen atom.

(2)

Anti H will have a negative nucleus and positive positrons orbiting it, regular H Atom will have a positive nucleus with negative electron orbiting.

ResultsPlus

Examiner Comments

This answer lists all of the four particles correctly for one mark but there is no mention of mass.

17 Anti-hydrogen atoms have been created at CERN. An anti-hydrogen atom consists of an anti-proton and a positron.

$\bar{p}$ $\bar{e}$

(a) Compare the properties of an anti-hydrogen atom with a hydrogen atom.

(2)

They both have the same mass. ~~[illegible]~~ They both have opposite charges.

ResultsPlus

Examiner Comments

A common answer. The question asks about the atoms so the use of 'they' is taken to mean the atoms. Scores 1 mark for the same masses.

17 Anti-hydrogen atoms have been created at CERN. An anti-hydrogen atom consists of an anti-proton and a positron.

(a) Compare the properties of an anti-hydrogen atom with a hydrogen atom.

(2)

~~Anti-hydrogen atom has negative charge of 1e.~~

They are of the same mass, they're both neutral.

Anti-hydrogen atom has negative nucleus and positive positron.

Hydrogen atom has positive ~~neutron~~ neucl nucleus and negative electron.

ResultsPlus

Examiner Comments

This does score two marks and has done so in the first line only.

ResultsPlus

Examiner Tip

It is important to read the question and apply your knowledge to the actual particles/atoms in the question.

Question 17 (b)

This calculation was generally well done with many candidates scoring the full three marks. Errors made were with writing the equation correctly but then forgetting to square *r* and failing to identify correctly the charge on the electron for both Q_1 and Q_2. Occasionally, having set the equation up correctly, candidates made calculator errors. A small number of candidates started with the wrong equation such as the potential equation for radial fields.

(b) Calculate the electrostatic force of attraction between the positron and the anti-proton.

Assume that the radius of the anti-hydrogen atom is 5.3×10^{-11} m.

(3)

$F = \frac{kQ_1Q_2}{r^2} = \frac{8.99\times10^{9} \times (1.6\times10^{-19})^2}{(5\times10^{-11})^2}$

$F = \frac{2.30144\times10^{-28}}{2.5\times10^{-21}} = 9.21\times10^{-8}$ N

Force = 9.21×10^{-8} N

ResultsPlus

Examiner Comments

An example of a calculator error, this scored 2 marks.

(b) Calculate the electrostatic force of attraction between the positron and the anti-proton.

Assume that the radius of the anti-hydrogen atom is 5.3×10^{-11} m.

(3)

$F = \frac{kQ_1Q_2}{r^2}$ $k = \frac{1}{4\pi\varepsilon_0} = 8.992 \times 10^9$

$\frac{(8.992 \times 10^9) \times (1.6 \times 10^{-19}) \times -(1.6 \times 10^{-19})}{5.3 \times 10^{-11}}$

$= -4.34 \times 10^{-18}$ N

Force = -4.34×10^{-18} N

ResultsPlus
Examiner Comments

This candidate has failed to square *r* and so gets 1 mark for correctly identifying the charges.

Question 17 (c)

This is where annihilation was the common answer. Candidates who picked up the significant difference in charge usually went on to score two marks but those answers accounted for only a small number of candidates. A very small number of candidates identified the charge difference but failed to make the link to magnetic or electric fields. This means that most candidates scored zero. The most common answer was 'annihilation' on the assumption that the anti-hydrogen would automatically come into contact with hydrogen. Another frequently seen idea was that anti-hydrogen was completely unstable and would decay.

(c) Scientists want to find out if anti-hydrogen atoms emit the same spectra as hydrogen atoms. Anti-protons are relatively easy to contain, however, it is very difficult to contain anti-hydrogen atoms for any period of time.

Explain why it is difficult to contain anti-hydrogen atoms compared with anti-protons.

(2)

Anti protons ~~[crossed out]~~ have a charge ~~[crossed out]~~ where they are easily detected and therefore stored.
Anti hydrogen is nuetral and ~~[crossed out]~~ so harder to detect and store.

ResultsPlus
Examiner Comments

A candidate who realises that the charges are different but is unable to apply this fact.

(c) Scientists want to find out if anti-hydrogen atoms emit the same spectra as hydrogen atoms. Anti-protons are relatively easy to contain, however, it is very difficult to contain anti-hydrogen atoms for any period of time.

Explain why it is difficult to contain anti-hydrogen atoms compared with anti-protons.

(2)

This is because they decay very quickly in comparason to anti-protons. This makes it hard to study them in such a short time period.

ResultsPlus
Examiner Comments

An example of the decay idea.

Question 17 (d) (i)

This is the part of the question where annihilation was mentioned in the question and although both particles were mentioned, the majority of candidates missed the x2 factor, getting the common wrong answer of 9.0×10^{10} J. 60% of candidates made this error and so scored 2 marks. Despite the fact that the mass was given in the question, some candidates tried to use the proton and electron mass given in the data.

(d) The technology suggested in the science fiction series, Star Trek, for powering the Starship Enterprise relied on antimatter. When an anti-hydrogen atom meets a hydrogen atom, they annihilate and produce energy.

(i) How much energy, in joules, would be produced by the annihilation of just 1 milligram of anti-hydrogen atoms?

(3)

$E = mc^2$, $E = (1 \times 10^{-3})(3 \times 10^8)^2$

$E = 9 \times 10^{13}$ J

Energy = 9×10^{13} J

ResultsPlus
Examiner Comments

The most frequently seen answer.

(d) The technology suggested in the science fiction series, Star Trek, for powering the Starship Enterprise relied on antimatter. When an anti-hydrogen atom meets a hydrogen atom, they annihilate and produce energy.

(i) How much energy, in joules, would be produced by the annihilation of just 1 milligram of anti-hydrogen atoms?

(3)

$\Delta E = c^2 \Delta m = (3 \times 10^8)^2 \times (1 \times 10^{-6}$ kg$) = 9 \times 10^{10}$ J

multiplied by 2 as the same mass of hydrogen atoms gets annihilated as well as the anti-hydrogen atoms

$= 1.8 \times 10^{11}$ J

Energy = ~~9×10^{10}~~ 1.8×10^{11} J

ResultsPlus
Examiner Comments

A small number of candidates managed to double the mass and score 3 marks.

Question 17 (d) (ii)

The use of (i) and (ii), in question part labelling, is a clue that these last two parts are linked. Even if candidates got the common wrong answer to (i), they should still have realised that the amount of energy required was very large, which was what the answer was. Again, annihilation appeared regularly but again this demonstrates that candidates are not thinking about what is being asked. Annihilation comes after antimatter has been produced but this was about the difficulty of actually producing it.

(ii) Anti-protons are required to produce anti-hydrogen atoms. The total production of anti-protons on Earth over the past 25 years adds up to only a few nanograms.

Suggest why so little anti-matter has been created.

(1)

They last for a very short time before anihilating and therefore are hard to capture.

ResultsPlus
Examiner Comments

An example of an answer that is trying to explain what happens after antimatter has been produced.

ResultsPlus
Examiner Tip

Answer the question that has been asked which is about the creation of antimatter. This answer talks about what might happen after antimatter is created.

(ii) Anti-protons are required to produce anti-hydrogen atoms. The total production of anti-protons on Earth over the past 25 years adds up to only a few nanograms.

Suggest why so little anti-matter has been created.

(1)

Anti-matter only exsists for a very short amount of time before annihilation.

ResultsPlus
Examiner Comments

Another example of talking about what might happen after it is produced.

Question 18 (a)

In general this calculation was well done with 75% of the candidates scoring the full three marks. Weaker candidates tried to use $E = mc^2$ or failed to convert eV to J. Where some candidates did lose 1 mark was in not showing the value of velocity to one more significant figure. They set up their calculation correctly but just wrote down the value given in the question. Candidates should remember that a 'show that' is used when the value found will be needed later. In this case, it was needed for the last part of the question, by which time most candidates had completely forgotten about it and therefore did not use it.

18 James Chadwick is credited with "discovering" the neutron in 1932.

Beryllium was bombarded with alpha particles, knocking neutrons out of the beryllium atoms. Chadwick placed various targets between the beryllium and a detector. Hydrogen and nitrogen atoms were knocked out of the targets by the neutrons and the kinetic energies of these atoms were measured by the detector.

(a) The maximum energy of a nitrogen atom was found to be 1.2 MeV.

Show that the maximum velocity of the atom is about 4×10^6 m s^{-1}.

mass of nitrogen atom = $14u$, where $u = 1.66 \times 10^{-27}$ kg

(3)

mass = 2.324×10^{-26} kg

1.2 MeV = 1.92×10^{-13} J

$E_k = \frac{1}{2} m v^2$

$1.9 \times 10^{-13} = \frac{1}{2}(2.3 \times 10^{-26}) v^2$

$3.8 \times 10^{-13} = 2.3 \times 10^{-26}\ v^2$

$v^2 = 1.65 \times 10^{13}$ $v = \sqrt{1.65 \times 10^{13}}$ = 4×10^6 m s^{-1}

ResultsPlus
Examiner Comments

An example of a candidate who does not show the value to one more significant figure.

ResultsPlus
Examiner Tip

In a 'show that' question the answer must always be given to one more significant figure than the value given in the question.

Question 18 (b) (i)

This was a relatively easy application of conservation of momentum although to get all three marks, candidates did need to to use *u* ,since that was an integral part of the masses of the particles involved. Some students missed out the *u* but wrote a clear staement of momentum before = momentum after and so scored 2 marks. Whilst appreciating that the *u* did cancel out, students should realise that when asked to demonstrate that an equation given is correct, they should include all of the steps.

(b) The mass of a neutron is N*u* (where N is the relative mass of the neutron) and its initial velocity is *x*. The nitrogen atom, mass 14*u*, is initially stationary and is then knocked out of the target with a velocity, *y*, by a collision with a neutron.

(i) Show that the velocity, *z*, of the neutron after the collision can be written as

$$z = \frac{Nx - 14y}{N}$$

(3)

$Nx = 14y + Nz$

conservation of momentum

$\frac{Nx - 14y}{N} = z$

ResultsPlus
Examiner Comments

An example of missing out the *u* but this did score 2 marks.

ResultsPlus
Examiner Tip

When justifying an expression that has been given, it is important to use the information given and to show all of the steps.

(b) The mass of a neutron is Nu (where N is the relative mass of the neutron) and its initial velocity is x. The nitrogen atom, mass 14u, is initially stationary and is then knocked out of the target with a velocity, y, by a collision with a neutron.

(i) Show that the velocity, z, of the neutron after the collision can be written as

$$z = \frac{Nx - 14y}{N}$$

(3)

initial momentum = final momentum

$Nux = Nuz + 14uy$

$Nz\cancel{u} = \cancel{u}(Nx - 14y)$

$z = \frac{Nx - 14y}{N}$ (shown)

ResultsPlus
Examiner Comments

A three mark answer. Some candidates included a 14u x0 for the initial momentum of the nitrogen. This was an excellent approach to the question but was needed in order to score 3 marks.

Question 18 (b) (ii)

This was a straightforward factual recall that kinetic energy is conserved in elastic collisions and the majority of candidates got it right. However, there were a number of incorrect answers. This is a simple bit of physics that all candidates should be able to recall. Some candidates said it was when momentum and kinetic energy were conserved and this answer was given the mark. However, some candidates gave a long list of options, one of which was kinetic energy, but in this case the mark was not given.

Question 18 (b) (iii)

This was another example where candidates were asked to justify a given expression, although some candidates had difficulty with this question and there was evidence of candidates trying unsuccessfully to work backwards. Candidates tried to square a difference in speed and then just move the square inside the bracket, showing a poor grasp of algebra. What was needed was a statement that the energy gained by the nitrogen was equal to the energy lost by the neutron. Candidates needed to write down expressions for the KE of the neutron before the event and after the event.

(iii) Explain why the kinetic energy E_k of the nitrogen atom is given by

$$E_k = \frac{Nu(x^2 - z^2)}{2}$$

(2)

$\frac{1}{2} Nux^2$ is initial KE of the neutron.

$\frac{1}{2} Nuz^2$ is final KE of the neutron

Since KE is conserved, the difference must be given to the nitrogen atom

ResultsPlus
Examiner Comments

This was all that was required for full marks but very few candidates scored 2 marks.

(iii) Explain why the kinetic energy E_k of the nitrogen atom is given by

$$E_k = \frac{Nu(x^2 - z^2)}{2}$$

(2)

$$E_k = \frac{p^2}{2m} = \frac{m^2v^2}{2m} = \frac{mv^2}{2} = \frac{Nu(x^2-z^2)}{2}$$

$v^2 = \text{initial}^2 - \text{final}^2$

$= x^2 - z^2$

ResultsPlus
Examiner Comments

Many candidates scored zero and this is a typical of the answers seen, with no words, a random couple of equations and then the given expression, just written down.

Question 18 (c) (i)

This proved to be a very difficult question for all but the most able. First of all candidates needed to remember to use the speed of the nitrogen atom from (a) which was on the previous page and then they were to use an equation that they hadn't derived, so perhaps didn't understand the significance of all of the symbols. Finally they needed to realise that they could use the given equation twice, once for the hydrogen atom and once for the nitrogen atom in order to equate two expressions of 2N*x* and so find N. Perhaps not surprisingly only a very small number of candidates managed this.

(c) The two equations in (b) can be combined and z can be eliminated to give

$$y = \frac{2Nx}{N+14}$$

(i) The maximum velocity of hydrogen atoms knocked out by neutrons in the same experiment was ~~30~~ 3.0 × 10^7 m s^{-1}. The mass of a hydrogen atom is 1u.

Show that the relative mass N of the neutron is 1.

(3)

$3.0 \times 10^7 = \frac{2Nx}{N+14}$

$3.0 \times 10^7 N + 42 \times 10^7 = 2Nx$

$N(3.0 \times 10^7 - 2x) = -42 \times 10^7$

$N = -42 \times 10^7 \div (3.0 \times 10^7 - 2(3.0 \times 10^6))$

$= 0.737$ (3sf)

ResultsPlus
Examiner Comments

This candidate tries to use the equation but with the wrong velocity so scores 1 mark and then does some creative arithmetic.

(c) The two equations in (b) can be combined and z can be eliminated to give

$$y = \frac{2Nx}{N+14}$$

(i) The maximum velocity of hydrogen atoms knocked out by neutrons in the same experiment was 3.0×10^7 m s^{-1}. The mass of a hydrogen atom is 1u.

Show that the relative mass N of the neutron is 1.

(3)

$y = \frac{2Nx}{N+14}$ $\qquad$ $3.0 \times 10^7 = \frac{2Nx}{N+1}$

$4 \times 10^6 = \frac{2Nx}{N+14}$

$4 \times 10^6 \times (N+14) = 2Nx$ $\qquad$ $(N+1) \times 3 \times 10^7 = 2Nx$

$4 \times 10^6 (N+14) = 3 \times 10^7 (N+1)$

$-(4 \times 10^6 - 3 \times 10^7) N = -(3 \times 10^7 - 5.6 \times 10^7)$

$2.6 \times 10^7 N = 2.6 \times 10^7$

$N = 1$

ResultsPlus

Examiner Comments

This is an example of an answer that scores 3 marks. It was decided to give the three marks for writing the two equations correctly. As it happens this candidate sucessfully works through the algebra.

(c) The two equations in (b) can be combined and z can be eliminated to give

$$y = \frac{2Nx}{N+14}$$

(i) The maximum velocity of hydrogen atoms knocked out by neutrons in the same experiment was [redacted] 3.0 $\times 10^7$ m s^{-1}. The mass of a hydrogen atom is 1u.

Show that the relative mass N of the neutron is 1.

(3)

$$3 \times 10^7 = \frac{2Nx}{15}$$

$$x = 2.25 \times 10^8 \text{ ms}^{-1}$$

$$\therefore 3 \times 10^7 = \frac{4.5 \times 10^8 N}{15}$$

$$N = \frac{15 \times 3 \times 10^7}{4.5 \times 10^8} = 1$$

ResultsPlus
Examiner Comments

At this level candidates should realise that they shouldn't do what this candidate has done. Has assumed N = 1 and uses this to find x and then substitutes x back into the equation to get N =1 again.

Question 18 (c) (ii)

The energy equation in (b) depending on kinetic energy being conserved and that equation was used to obtain the equation in (c), so the expected answer was that not all collisions are elastic. It was decided to accept a comment that the particles has speeds approaching the speed of light and with those two possible answers just over half of candidates scored the mark.

Paper Summary

In order to improve their performance candidates should:

Ensure they have a thorough knowledge of the physics for this unit.

Read the question and answer what is asked.

For descriptive questions, make a note of the marks and include that number of different physics points.

Show all their workings in calculations.

For descriptive questions, try to base the answer around a specific equation which is quoted.

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