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Examiners' Report
June 2011

GCE Physics 6PH04 01

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June 2011

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Introduction

The overall performance of the candidates on this paper was very similar to that produced on previous papers. However, it appears some candidates were not familiar with the format of question 16. Those that saw past the spreadsheet and thought about the context and the physics of the alpha scattering experiment and then made an attempt at the question, went on to score some marks.

The responses for the other questions covered the full range of marks allowable with full marks being scored frequently for all question parts. Candidates were able to demonstrate their knowledge and understanding of the full range of topics in this unit.

Section A Multiple Choice (MC) questions

The order of most correct answers to least correct was 7, 8, 3, 4, 9, 6, 10, 1, 5, 2.

The performance on some of the multiple choice questions was disappointing. Question 3, which asked for the unit of the time constant for a RC circuit, was expected to score very well but only 59% of candidates got it right. Question 10 was another straightforward question about the use of high energies in particle production, but again only 31% got this one right.

The MC questions are at the start of the paper and cover 10 different topic areas; therefore, the candidates have to recall a lot of physics, in a short space of time, at the start of the exam. They might perform better on these questions if they started with question 11 and 12, which are usually quite straightforward and then went back to the MC questions when they have settled into the examination.

Question 11 (a)

Most candidates were able to derive the equation as asked and scored both marks. Candidates should be encouraged to make a clear statement of the equation/equations they are using before either substituting one equaqtion into another or equating two different expersions for a given variable. This question asked for the given equation to be derived. t is incorrect to take the equation and work backwards to show that p=mv. Candidates who did this scored 0.

11 The de Broglie wave equation can be written $\lambda = \sqrt{\frac{h^2}{2mE_k}}$ where m is the mass of a particle and E_k is its kinetic energy.

(a) Derive this equation. Use the list of equations at the end of this question paper. **(2)**

$\lambda = \frac{h}{p}$ $\quad E_k = \frac{p^2}{2m}$ $\quad p = \sqrt{2m \times E_k}$

$\lambda = \frac{h}{\sqrt{2m \times E_k}}$

$= \sqrt{\frac{h^2}{2mE_k}}$

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Examiner Comments

A well laid out answer where the candidate's work can be clearly followed.

11 The de Broglie wave equation can be written $\lambda = \sqrt{\frac{h^2}{2mE_k}}$ where m is the mass of a particle and E_k is its kinetic energy.

(a) Derive this equation. Use the list of equations at the end of this question paper. **(2)**

$\lambda = \sqrt{\frac{h^2}{\cancel{2}m\cancel{\frac{1}{2}}mv^2}} = \frac{h}{\sqrt{m^2v^2}} = \frac{h}{mv}$ $\quad p = mv$

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

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Examiner Comments

A reverse argument answer.

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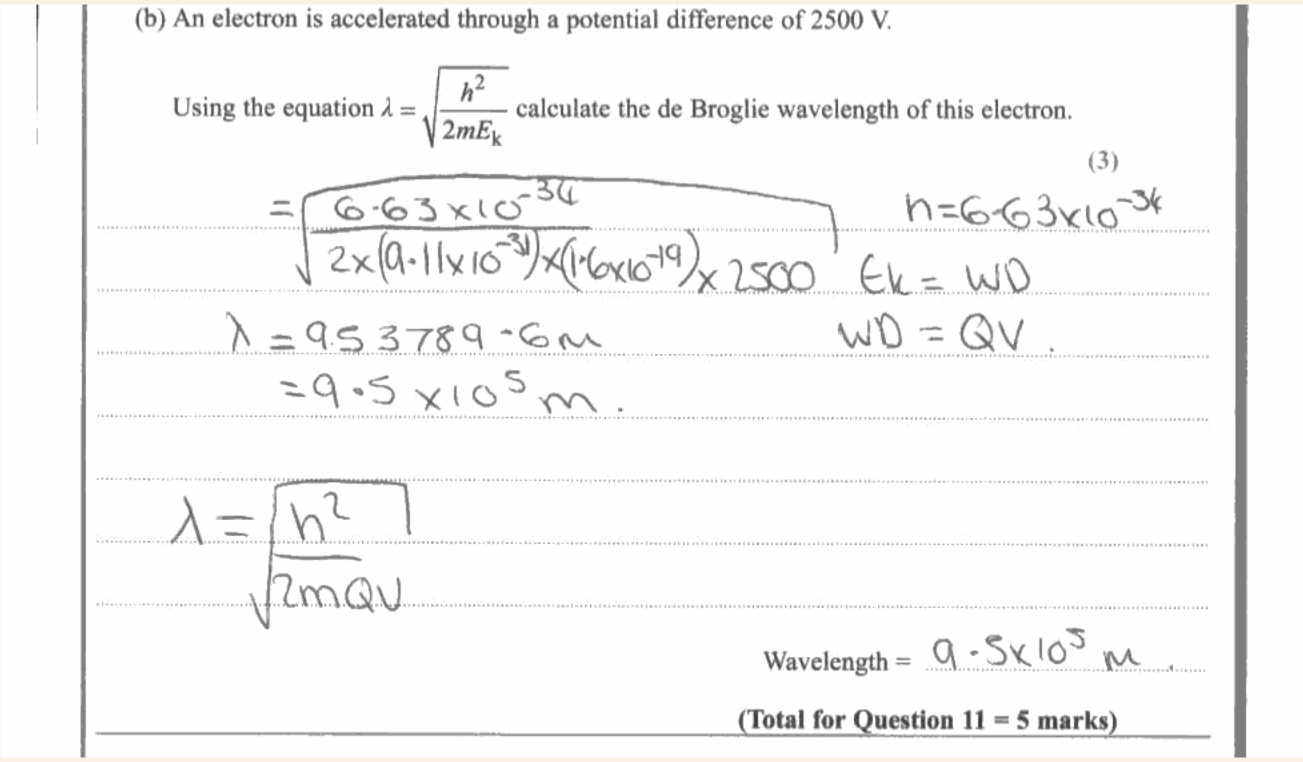
Examiner Tip

Do not take the equation and work backwards.

Question 11 (b)

A significant number of candidates scored full marks for the calculation but the most common error made was in not realising that KE was eV. Less able candidates confused their symbols and used KE =1/2mv^2 substituting potential difference for velocity. Additionally, some candidates forgot the square h or forgot to find a square root.

Although the question asked the candidates to use the equation, some chose to go back and find the kinetic energy first. They were not penalised for this because they had effectively penalised themselves in terms of time spent on a longer method.


(b) An electron is accelerated through a potential difference of 2500 V.

Using the equation $\lambda = \sqrt{\frac{h^2}{2mE_k}}$ calculate the de Broglie wavelength of this electron.

(3)

$= \sqrt{\frac{6.63 \times 10^{-34}}{2 \times (9.11 \times 10^{-31}) \times (1.6 \times 10^{-19}) \times 2500}}$ $\quad h = 6.63 \times 10^{-34}$

$E_k = WD$

$\lambda = 953789.6 m$ $\quad WD = QV$.

$= 9.5 \times 10^5 m$.

$\lambda = \sqrt{\frac{h^2}{2mQV}}$

Wavelength = 9.5×10^5 m.

(Total for Question 11 = 5 marks)

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Examiner Comments

Value of h hasn't been squared.

(b) An electron is accelerated through a potential difference of 2500 V.

Using the equation $\lambda = \sqrt{\frac{h^2}{2mE_k}}$ calculate the de Broglie wavelength of this electron.

(3)

$h = 6.63 \times 10^{-34}$ J s

$m_e = 9.11 \times 10^{-31}$ kg

$E_k = 4 \times 10^{-16}$ J

$$\lambda = \sqrt{\frac{(6.63\times10^{-34})^2}{(2\times9.11\times10^{-31}\times4\times10^{-16})}}$$

$\lambda = 2.45 \times 10^{-11}$ m

$V = W/Q$

$W = E_k$

$E_k = VQ$

$E_k = 2500 \times 1.6\times10^{-19}$ C

Wavelength = 2.45×10^{-11} m

(Total for Question 11 = 5 marks)

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Examiner Comments

A well laid out answer that is clear to follow.

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Examiner Tip

When substituting into an equation care must be taken to ensure all steps are included.

Question 12

Part (a) was a straightforward calculation of values, plotting of points and drawing a line of best fit. Quite a few candidates did score both marks, but significant errors were also made. This question is based on practical work and so the values for the table should be to 3 significant figures, consistent with the other values in the table. Some candidates chose to draw the line first and then read the missing points off the graph whilst others having calculated the values and plotted them failed to draw the line.

Part (b) required candidates to understand the log relationship and this was more challenging. Many did not realise that they had to find the gradient and tried, usually unsuccessfully, to substitute into the formula, losing both marks. Of those candidates who did find the gradient most of them omitted a unit when they equated the gradient to the constant. Normally this would have resulted in the last mark not being awarded, however because of the difficulty of the concept involved and there only being two marks, it was decided not to penalise the lack of a unit. This does not set a precedent for future papers. Candidates need to realise the possible penalty of working to too few significant figures. Since the range of gradients we were looking for was 0.061 to 0.066, candidates who worked to 1 significant figure 0.06 did not get the mark.

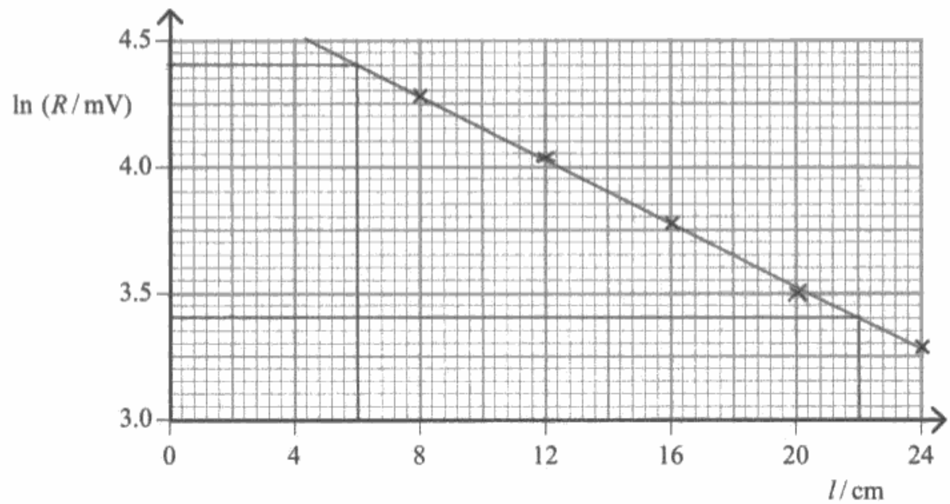
An example of an answer that scores full marks. The unit wasn't being marked on this occasion but lnmV/m is not acceptable. Candidates need to know that e has no units so the unit of the constant is cm^{-1} or in this case where the candidate has converted to metres, m^{-1}.

12 A student carries out a practical involving a length of jelly. She places an infrared transmitter at one end and a receiver at the other. She obtains the following results.

Length of jelly l / cm	Receiver reading R / mV	ln (R / mV)
8.0	72	4.28
12.0	57	4.04
16.0	43	3.76
20.0	33	3.50
24.0	26	3.26

(a) Complete the table above and the graph below.

(2)



(b) The student reads that infrared light in jelly can be mathematically modelled using the equation $R = R_0 e^{-\mu l}$ where μ is a constant.

Use your graph to determine a value of μ for the jelly.

(2)

$\ln R = \ln R_0 - \mu l \qquad y = mx + c$

$\ln R = -\mu l + \ln R_0$

$\mu = \text{gradient} = \frac{\Delta y}{\Delta x} = \frac{4.4 - 3.4}{0.06 - 0.22} = -6.25$

$\mu =$ 6.25 (lnmV/m)

(Total for Question 12 = 4 marks)

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Examiner Comments

This scores full marks. Candidate has converted cm to m^{-1}. The unit was not marked this time but if it had been this is not an acceptable unit. Candidates need to know that e has no units so the unit is either m^{-1} or cm^{-1}.

Values calculated and plotted but the graph hasn't been drawn.

12 A student carries out a practical involving a length of jelly. She places an infrared transmitter at one end and a receiver at the other. She obtains the following results.

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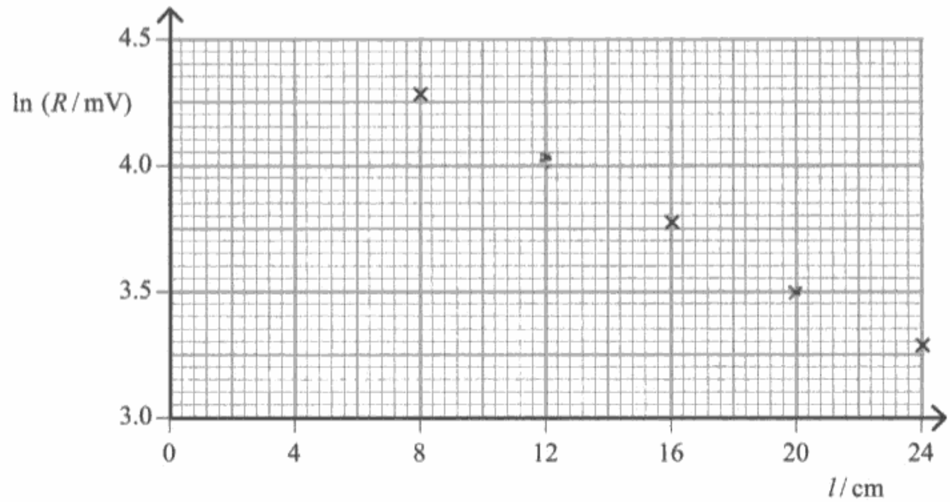
(a) Complete the table above and the graph below.

(2)



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Examiner Comments

The graph is not complete.

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Examiner Tip

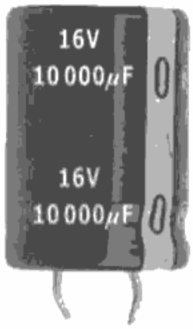
A graph is not complete until a line of best fit has been drawn.

Question 13

A lot of candidates were successful with part (a). The tolerance in the question was a tolerance on the capacitance of the capacitor and candidates were expected to show this in their working. A number of candidates found 120% of V while others did a calculation of Q and then found 120% of that. Whilst this could give the correct numerical answer, it was an incorrect method and scored two of the three marks. It was only a minority of candidates who struggled with the percentage increase or could not convert microfarads to farads.

Quite a few candidates were successful with part (b) but a number of different mistakes were made. Incorrect equations were used, some candidates used the nominal capacitance rather than the maximum value and quite a few candidates confused their symbols for units with the symbols for quantities. This meant that they used the charge in (a) measured in Coulombs as their value of capacitance, symbol C.

13 A student needs to order a capacitor for a project. He sees this picture on a web site accompanied by this information: capacitance tolerance ±20%.



Taking the tolerance into account, calculate

(a) the maximum charge a capacitor of this type can hold.

(3)

Q=VC 20% of 0·16C is 0·032C

= 16 × (10000×10⁻⁶)

= 0·16C 0·16 + 0·032 = 0·192C

Maximum charge = 0·192C

(b) the maximum energy it can store.

(2)

$W = \frac{1}{2}CV^2$

$= \frac{1}{2} \times 0.192 \times (16)^2$

$= 24.576\ J$

Maximum energy = 24.6 J (1dp)

(Total for Question 13 = 5 marks)

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Examiner Comments

Candidate does a Q=CV calacution and adds the 20% at the end, then substitutes the value of charge for capacitance. This scored 2 of the (a) marks and 0 of the (b) marks.

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Examiner Tip

Make sure you don't confuse the symbol C for capacitance with the symbol C for the unit of charge, the coulomb.

Question 14

This question was best answered by candidates who focussed on the physics content of this unit, in this case electric fields. The most able candidates did realise that this was a question about a uniform field, leading to a constant force and uniform acceleration. Marks were available for both the physics of the situation and the interpretation of the graph, yet very few who referred to the graph commented on the uniform acceleration. The majority of students focussed on the ball acquiring charge and being repelled from one plate/attracted to the other plate. This was an acceptable way into the question but what was worth 1 mark was repeated several times, gaining no more credit.

In order to score full marks, some reference to the graph had to be made.

In reality, very few candidates did refer to the graph and the least able candidates interpreted the increasing negative velocity as a decrease in velocity showing a very poor understanding of graphs in more than one quadrant. Again, it was the weaker candidates who tried to answer this question in terms of electromagnetic induction and Faraday's Law.

Because there were six marking points for a maximum of four marks, most candidates did score some marks but where it was common to award 1,2 or 3 marks, it was not often that the full 4 marks were awarded.

An example of an answer that focuses on the aquisition of charge only, making just one physics point. There is no reference to the graph at all.

Explain the shape of the velocity-time graph for the ball from when it leaves one plate until it returns to the same plate. Ignore the weight of the ball.

(4)

as the ball ~~leaves~~ hits the plate it has began to acomoldated a charge. of the same polarity as the plate. ~~it is repelled away from~~ the ball stays stuck until the charges are equal and no electrostatic force atracts it to that plate. It moves away from the plate and becomes atracted to the other plate eventually hitting it. due to oposite charges atracting it remains attached to the plate until the charge is transfered it then swings back and hits the first plate, starting the process again.

(Total for Question 14 = 4 marks)

first plate, starting the process again. It can keep going as the electrostatic forces give it a little "tug" increasing its velocity towards the plate, replacing its kinetic energy that it lost through air resistance.

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Examiner Comments

Without necessarily understanding the physics, the graph shows uniform acceleration and a sudden change of direction. A student could start here and then try to fit this to the situation.

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Examiner Tip

If a question asks for an explanation of a graph, your answer must refer to the graph.

Explain the shape of the velocity-time graph for the ball from when it leaves one plate until it returns to the same plate. Ignore the weight of the ball.

(4)

* Initially, the velocity increases as it travels over towards a plate, ~~and increases~~ accellerating due to the field it's in.
* it then hits the plate causing very rapid deceleration and a change in direction, which is shown on the graph by an extremely steep gradient, and the line becoming negative to show negative velocity.
* the ball then continues to accelerate to the other plate in the same manner as before, but in the opposite direction.

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Examiner Comments

This is an example of an answer that does look at the graph and scores 2 marks. However, there does need to be a link to what causes the acceleration in order to score more marks.

Explain the shape of the velocity-time graph for the ball from when it leaves one plate until it returns to the same plate. Ignore the weight of the ball.
(4)

- Carbon coated tennis ball is charged by plate.
- When the ball leaves one plate the velocity increases steadily so it is accelerating uniformly.
- It accelerates uniformly because it is in a uniform electric field because the plates are parallel.
- This means that the force acting on the ball is the same throughout the field. F = EQ (charge stays the same & electric field is constant so force is).
- When the ball reaches the other plate its velocity drops to 0, then it moves in other direction because it has lost its charge.

(Total for Question 14 = 4 marks)

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Examiner Comments

This scored 4 marks for the uniform acceleration. force and uniform field. In this case it doesn't matter but the last part wasn't good enough for the velocity mark since it only refers to the velocity falling to zero rather than becoming negative.

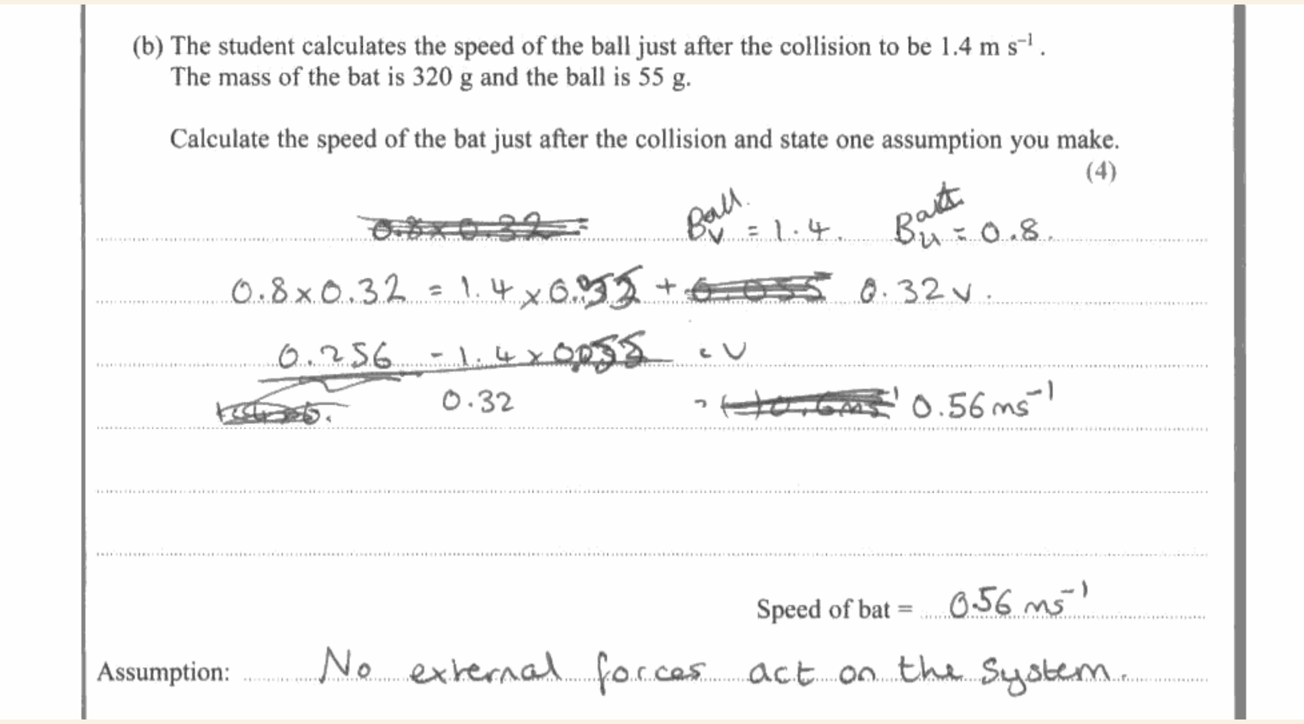
Question 15

(a)Previous comments about how to solve this type of problem (i.e. use conservation of energy and do not use equations of motion) appear to have been successful with far fewer candidates using the wrong method.

In part (b) the majority of candidates were able to correctly apply the conservation of momentum to obtain the correct answer. Again a few candidates worked to too few significant figures so that their arithmetic could not be checked and a very small minority assumed that the ball stuck to the bat on impact. What was disappointing was how few candidates could state a valid assumption, the most common one being given was the momentum wa conserved. Candidates need to understand that applying a conservation law does not imply an assumption.

Part (c) was about the type of collision. Candidates need to know that an inelastic collision is where there the KE after the event is less than the KE before the event. It is not just that KE is not conserved. If no forces are acting, so that momentum is conserved then there cannot be an increase in KE. The question was based on the values obtained by a student in an experiment, so when the calculation showed a very small increase in KE (0.004 J), candidates were expected to realise that this was related to the uncertainity in the readings so that the values were so close that this was an elastic collision.

Part (d) took this further and expected candidates to realise that due to the uncertainties in the values, this could have been an inelastic collision. This should have answered in terms of the uncertainty in the readings, i.e. identifying that x was measured to the nearest cm and commenting that the % error in x would be greater than the % error in h. None of the candidates did this, so the mark scheme was opened up to allow for sensible reasons why x might be inaccurate and the effect this would have on the calculations. Comments had to refer to the experiment and not be vague general answers such as 'there might be parallax errors'.



(b) The student calculates the speed of the ball just after the collision to be 1.4 m s^{-1}.
The mass of the bat is 320 g and the ball is 55 g.

Calculate the speed of the bat just after the collision and state one assumption you make.

(4)

Ball B_v = 1.4.   Bat B_u = 0.8.

0.8 × 0.32 = 1.4 × 0.055 + 0.32v.

(0.256 − 1.4 × 0.055) / 0.32 = v

= 0.56 ms^{-1}

Speed of bat = 0.56 ms^{-1}

Assumption: No external forces act on the System.

(c) Determine whether the collision was elastic or inelastic.

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

(3)

KE before = $0.5 \times 0.32 \times 0.8^2$

= 0.1024 J.

KE After = $0.5 \times 0.035 \times 1.4^2 + 0.5 \times 0.32 \times 0.56^2$.

= 0.1047 J

The collision is in elastic.

(d) Discuss your conclusion with reference to possible uncertainties in the measurements of *x*.

(2)

The uncertainty in x ~~would~~ could change the speed in x which would change the energy within the system.

(Total for Question 15 = 11 marks)

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Examiner Comments

Candidate has used some 'show that' values and some calcuated values but even so gets a very small difference indicateing an elastic collision. The answer to (d) is too vague for merit.

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Examiner Tip

Discussing a conclusion is best done in terms of % uncertainty.

(b) The student calculates the speed of the ball just after the collision to be 1.4 m s^{-1}.
The mass of the bat is 320 g and the ball is 55 g.

Calculate the speed of the bat just after the collision and state one assumption you make.

(4)

Speed ball before: ~~s u v a t~~ s u v a t

~~-9.8~~ ~~u=0~~ 0.1 0 1.4 -9.8

u=0

Conservation of momentum

0.320 × 0.~~7~~7 + 0 = 1.4 × 0.055 + x × 0.320

0.169 = x × 0.320

0.529 ~~0.560~~ = x

Speed of bat = 0.53 ~~0.56~~ ms^{-1}

Assumption: ~~Ball has no velocity at~~ start ~~bat top of motion)~~ ~~[illegible]~~ Assuming ball mass constn. no rock chipped off

(c) Determine whether the collision was elastic or inelastic.

(3)

Energy	before	after
Bat	~~0.1024~~ 0.0949	~~0.0508~~ 0.0448
Ball	0	0.0539
Total	~~0.1024~~ 0.0949	~~0.1047~~ 0.0987

Increase in energy (?!?) Elastic as no energy lost.

(d) Discuss your conclusion with reference to possible uncertainties in the measurements of x.

(2)

There is clearly a problem with this experiment as energy can not be gained. This suggests an uncertainty with the value of x, as it may be too big. To measure the max height reached is hard as it does not stay at its max height for long, so it has an error.

(Total for Question 15 = 11 marks)

ResultsPlus
Examiner Comments

A poorly laid out momentum calculation with few words to help, but correct speed found so does score 3 marks for (b). In (d) candidate does at least acknowledge that KE shouldn't increase and goes on correctly, to suggest that it is because of recording a height for a moving ball.

ResultsPlus
Examiner Tip

Set work out clearly, use sybols for equations before substituting values in so that the examiner can clearly see what has been done.

(b) The student calculates the speed of the ball just after the collision to be 1.4 m s^{-1}.
The mass of the bat is 320 g and the ball is 55 g.

Calculate the speed of the bat just after the collision and state one assumption you make.

(4)

$m_1 v_1$ ~~$+ m_2 v_2$~~ $= m_1 v_1 + m_2 v_2$

(320×0.8) ~~$+ 55$~~ $= (320 v_1) + (55 \times 1.4)$

$256 = 320 v_1 + 77$

$256 - 77 = 320 v_1$

$179 = 320 v_1$

$179/320 = v_1 = 0.6 ms^{-1}$

Speed of bat = $0.6 ms^{-1}$

Assumption: ~~That it was an elastic collision and both energy~~ Momentum was conserved

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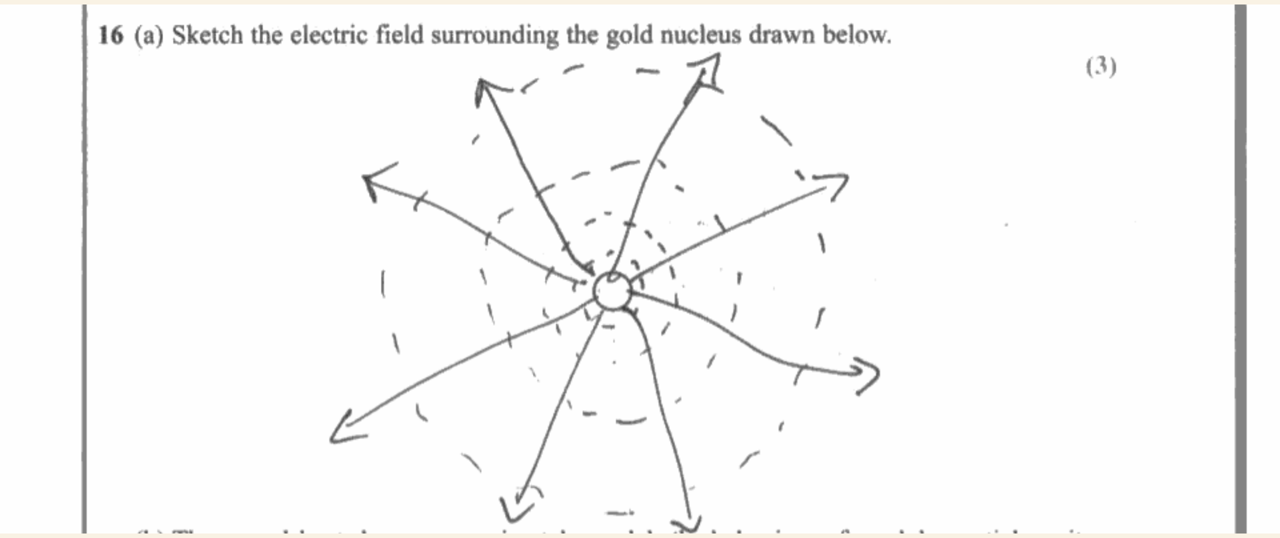
Examiner Comments

Candidate should work to the same number of significant figures as in the question. This is an exampe of a candidate who thinks the assumption of that momentum is conserved.

Question 16 (a)

The drawing of electric field lines has been set in previous examinations and there is evidence that candidates are taking note of the previous feedback that has been given, with nearly 60% of candidates scoring 3 marks. Marks are lost through lines not being straight and not equispaced. Candidates should be encouraged not to draw too many lines as this is when the errors usually occur.



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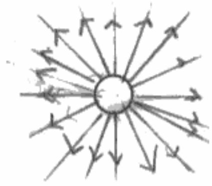
Examiner Comments

This scored 1 mark for the direction of the field. The lines are neither straight or equispaced.

16 (a) Sketch the electric field surrounding the gold nucleus drawn below.

(3)



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Examiner Comments

This scores 2, the lines are straight but not equispaced.

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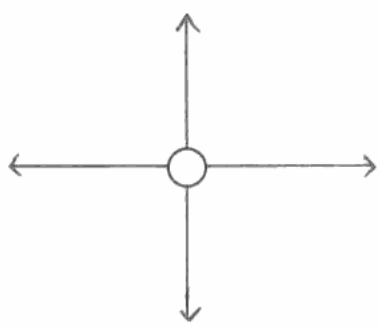
Examiner Tip

When drawing field lines, the more you draw the more difficult it becomes to get the marks. Don't draw too many!

16 (a) Sketch the electric field surrounding the gold nucleus drawn below.

(3)



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Examiner Comments

A perfect answer.

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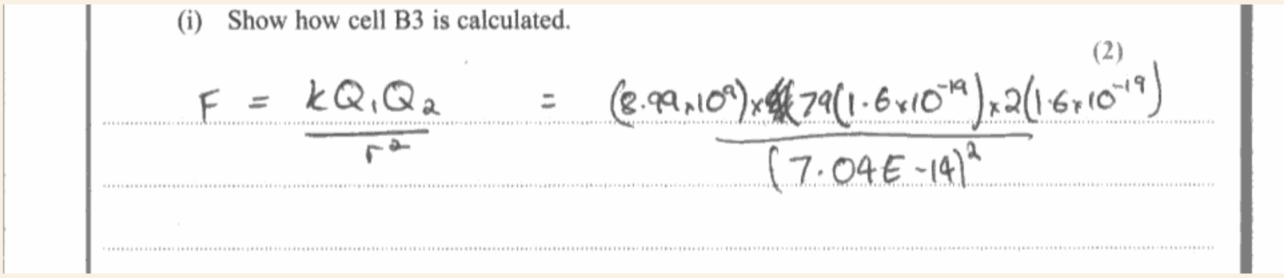
Examiner Tip

We require a mimimum of four lines. There is no need to draw more and a ruler will help you to draw a staright line.

Question 16 (b) (i)

Part (b) of this question proved very challenging to most candidates with a large number making no attempt at all. Spreadsheets are covered in the 'How Science Works' criteria, page 165 of the specification. There have been a number of spreadsheet questions on other papers but this was the first time that the use of E was used to indicate the power of ten in each cell. This is correct spreadsheet notation but possibly some candidates had not seen it. When faced with a question like this which has an unfamiliar format, candidates do need to try to think of the physics being asked. This question was about the force acting on an alpha particle as it approached a gold nucleus and how that force could be used to determine speed and displacement. In this type of question, candidates can answer in terms of conventional symbols, cell notation or numerical values.

In (b)(i) candidates needed to identify the equation for Coulomb's Law and use the correct values of the two charges. This was the best answered part of the question but still only 30% of the candidates scored 2 marks.


(i) Show how cell B3 is calculated.

(2)

$$F = \frac{kQ_1Q_2}{r^2} = \frac{(8.99\times10^9)\times 79(1.6\times10^{-19})\times 2(1.6\times10^{-19})}{(7.04E-14)^2}$$

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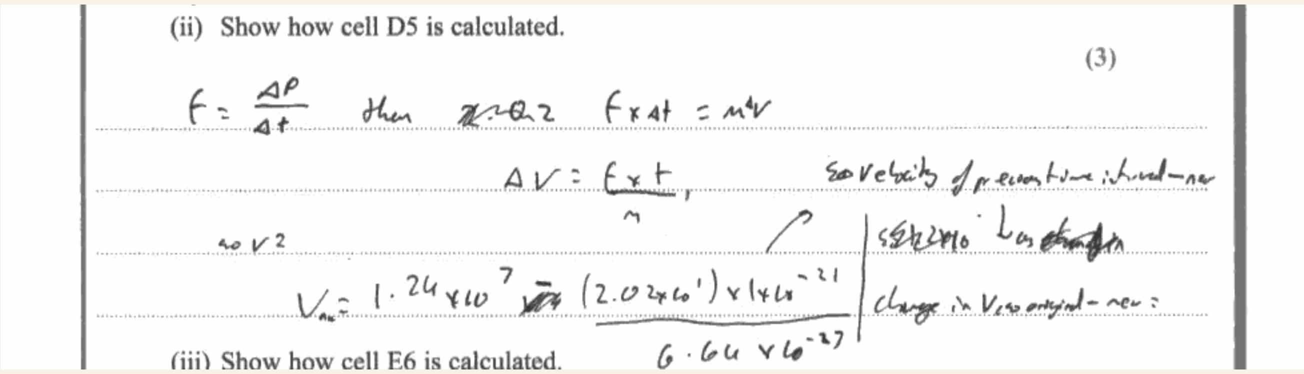
Examiner Comments

A correct answer that scored both marks. The candidate could have left the denominator as r^2 and still gain both marks.

Question 16 (b) (ii)

(ii) Momentum is introduced into the specification in unit 4 and candidates should be looking for questions where they will be expected to use force as rate of change of momentum. This question required candidates to realise that if you had a force and a time, then you could find a velocity change. Most candidates who even attempted this ignored the velocity change or wrongly assumed u=0. Candidates who did this were, at least, using the correct concept and so did score some marks. 70% of candidates scored 0 for this part.


(ii) Show how cell D5 is calculated.

(3)

$F = \frac{\Delta p}{\Delta t}$ then $F \times \Delta t = m\Delta v$

$\Delta v = \frac{F \times t}{m}$

$V = 1.24 \times 10^{7} - \frac{(2.02 \times 10^{1}) \times 1 \times 10^{-21}}{6.64 \times 10^{-27}}$

(iii) Show how cell E6 is calculated.

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Examiner Comments

A rare example of an answer that scored 3 marks, using conventional symbols and numerical values. Having got to a change in velocity, this candidate realised that because it is a replusive force, there is a negative sign in the calculation.

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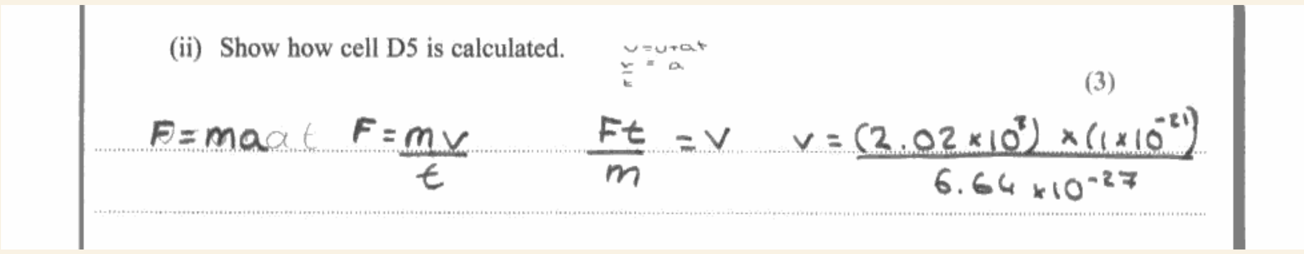
Examiner Tip

A key component of unit 4 is that force is rate of change of momentum. Writing that down correctly scores 2 marks.


(ii) Show how cell D5 is calculated.

(3)

$v = u + at$

$F = ma$ $F = \frac{mv}{t}$ $\frac{Ft}{m} = v$ $v = \frac{(2.02 \times 10^{1}) \times (1 \times 10^{-21})}{6.64 \times 10^{-27}}$

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Examiner Comments

A correct start but candidate uses v instead of v-u.

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Examiner Tip

Remember, that acceleration when measured for an object that is already moving, is defined as a = (v-u)/t. If the objects starts from rest then u =0 and calcuation becomes a=v/t.

(ii) Show how cell D5 is calculated.

(3)

Impulse = $F \times t$

$mv - mu = F \times t$ $\quad u = 0$

$mU = F \times t$

$D5 = \dfrac{B5 \times C5}{6.64 \times 10^{-27}}$

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Examiner Comments

An example where the candidate used cell notation and starts correctly but makes a wrong assumption about u so loses the third mark.

Question 16 (b) (iii)

Again many candidates left this blank and the most common answer was that distance = speed x time. This scored 1 mark. Very few candidates were able to follow through the idea that if there was a force, there was an acceleration and therefore a changing speed so an average velocity had to be used. Only 3% of the candidates scored 2 marks.

Question 16 (b) (iv)

Conceptually candidates found this very difficult and again there were many blank answers.

Question 16 (c)

In the main, this was well answered with quite a lot of candidates scoring three marks. The most common mistake was to make no reference to the mass of the atom. This is an example of where candidates need to read the question, in this case the conclusions, not the actual results. A lot of candidates spent a long time going through the results before starting to answer the question.

*(c) Describe the conclusions Rutherford reached about the structure of gold atoms as a result of the alpha particle scattering experiments.

(3)

Most alpha particles went straight through ~~pass~~ therefore the atom is mainly empty space. A few were deflected slightly as they were near the nucleus. Very few were deflected at angles greater than 90 or came back. ~~Those were the few~~ which showed there is a small nucleus at the centre which only affected a few particles as the rest went through

(Total for Question 16 = 14 marks)

ResultsPlus
Examiner Comments

This scores 1 because there is no reference to either the mass of the atom or its charge.

ResultsPlus
Examiner Tip

Don't waste time giving information that hasn't been asked for. There is no credit in saying 'most of the atoms went straight through' or references to deflection.

*(c) Describe the conclusions Rutherford reached about the structure of gold atoms as a result of the alpha particle scattering experiments.

(3)

Only very few alpha particles were deflected by the gold atoms which suggested that the atom was mainly empty space. The ones that were deflected, deflected at very large angles some alpha particles deflected straight back this suggested that the gold nucleus was a lot heavier than an alpha particle.

(Total for Question 16 = 14 marks)

ResultsPlus

Examiner Comments

This only scores 1 mark for the idea of empty space.

*(c) Describe the conclusions Rutherford reached about the structure of gold atoms as a result of the alpha particle scattering experiments.

(3)

The conclusion was, most of the atom is empty space most of the mass is in the positively charged nucleus at the centre. of the atom and the electrons ~~[illegible]~~ orbit round it.

ResultsPlus

Examiner Comments

A precise answer that answers the question and scores 3 marks.

ResultsPlus

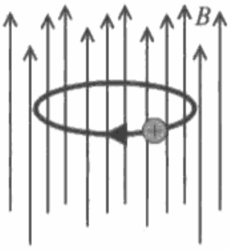
Examiner Tip

Answer the question that is being asked not the one that was set in a previous paper.

Question 17 (a)

The concept of a force on a conductor/charged particle and circular motion are again key components of this unit. It was disappointing how few candidates scored 2 marks, only 20%. The most common score was 1 mark and that could have been given for either of the marking points. Many candidates identified a force acted because the motion was at right angles to the field but didn't go on to say that the force was at right angles to the motion.

17 A strong magnetic field of flux density *B* can be used to trap a positive ion by making it follow a circular orbit as shown.



(a) Explain how the magnetic field maintains the ion in a circular orbit. You may add to the diagram above if you wish.

(2)

The force acts at right angles to the direction of ~~the~~ the ion causing centripetal acceleration

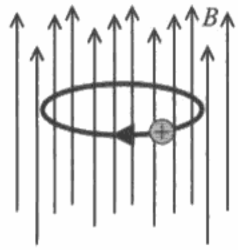
ResultsPlus
Examiner Comments

This represents a minimum answer that did score 2 marks. It would have been better if the candidate had written direction of motion of the ion.

ResultsPlus
Examiner Tip

You need to be able to recall that whenever there is a charged particle moving in a magnetic field, there is a force acting perpendicular to the motion of the charged particle.

17 A strong magnetic field of flux density B can be used to trap a positive ion by making it follow a circular orbit as shown.



(a) Explain how the magnetic field maintains the ion in a circular orbit. You may add to the diagram above if you wish.

(2)

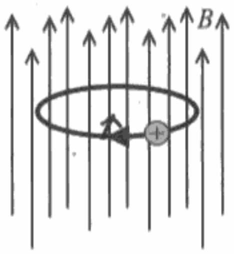
The magnetic field creates a force perpendicular to the direction of motion. This creates a circular orbit.

ResultsPlus

Examiner Comments

This example does get the force mark but fails to expalin why it causes circular motion.

17 A strong magnetic field of flux density B can be used to trap a positive ion by making it follow a circular orbit as shown.



(a) Explain how the magnetic field maintains the ion in a circular orbit. You may add to the diagram above if you wish.

(2)

exerts a force towards the centre of the circle giving in a centrapetal force. magnetic fields exert a force on moving charges.

ResultsPlus

Examiner Comments

This example has the idea of a force to the centre of a circle as a centripetal force but nothing about the force itself.

Question 17 (b)

This was generally well answered with many candidates scoring full marks. We were looking for the right bits of physics being used and did not follow the arithemetic through to the end. If we had done so, the marks might have been lower. Candidates should be encouraged to set their work out clearly.

(b) Show that the mass m of the ion will be given by

$$m = \frac{Bq}{2\pi f}$$

where q is the charge on the ion and f is the number of revolutions per second.

(3)

$T = \frac{1}{f}$ $\quad Bq\cancel{v} = \frac{mv^{\cancel{2}}}{r}$

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

$\frac{Bq}{2\pi f} = m$

ResultsPlus

Examiner Comments

The candidate starts out correctly, equating the magnetic force as the centripetal force but the leap to the correct answer is too great. This scored 2 marks.

(b) Show that the mass m of the ion will be given by

$$m = \frac{Bq}{2\pi f}$$

where q is the charge on the ion and f is the number of revolutions per second.

(3)

$r = \frac{mv}{BQ}$ $\quad \frac{mv^{\cancel{2}}}{r} = Bq\cancel{v}$

$r = \frac{mv}{BQ}$, $\quad m = \frac{BQr}{v}$

So, $m = \frac{Bq\cancel{r}}{\cancel{r}\omega}$ $[v = r\omega]$

$\therefore m = \frac{Bq}{2\pi f}$ $[\omega = 2\pi f]$.

ResultsPlus

Examiner Comments

A well laid out answer that is clear to follow.

ResultsPlus

Examiner Tip

Always set your work out clearly showing all of the steps taken.

Question 17 (c) (i)

Scores of 0,1 and 2 were awarded equally. This was a good test of a candidate's ability to spot a simple explanation from a rather complicated situation. Some candidates spent too long talking about the horizontal motion and missed the point about the vertical motion. Others tried to use Faraday's and lenz's Laws.

(i) Explain how the electric field prevents the ion moving vertically.

(2)

An electric field is a region where a charged particle feels a force. If the force is equal in all directions the ion will be suspended, equaly repelled/attracted from each side.

ResultsPlus
Examiner Comments

This is too general an answer, it does not refer specifically to the vertical motion. Also it is giving the examiner a choice of answers: repel or attract, and this never gained credit.

ResultsPlus
Examiner Tip

Never give an examiner a choice, you will not get a mark.

(i) Explain how the electric field prevents the ion moving vertically.

(2)

As the magnetic field is positive above and below the ion it means it will repel. And because the field is uniform it will not move vertically.

ResultsPlus
Examiner Comments

Incorrect reference to a magnetic field.

ResultsPlus
Examiner Tip

Read the question carefully. This is about electric fields but the answer refers to magnetic fields.

(i) Explain how the electric field prevents the ion moving vertically.

(2)

Opposites attract so the positive ion is attracted to both negative sides and repelled from the positive sides, which stop it moving up or down.

ResultsPlus

Examiner Comments

This answer implies that both the negative and positive sided affect the vertical motion.

Question 17 (c) (ii-iii)

The idea of working out three millionths of the mass of a sulphur atom proved too challenging for most candidates. It was rare to award one mark because candidates who understood what to do did it correctly and scored both marks but the majority had no idea at all.

Many candidates scored well in (iii) although a significant number omitted one stage of the three-stage process and it was random as to which stage was omitted. Some candidates incorrectly used the proton mass as the value for u. Both of these values are provided in the list of data and candidates need to know when they should be used.

(ii) This device is known as a Penning Trap. It can be used to determine the mass of an ion to an accuracy of 3 parts in 10 million.

Confirm that the mass of a sulphur ion can be measured to the nearest 0.00001u.

mass of sulphur ion = 32.0645u

(2)

$\frac{3}{10000000} \times 32.0645 = 9.6 \times 10^{-6}$ u

$\approx 1 \times 10^{-5}$ u

(iii) Under certain conditions nuclei of sulphur emit a gamma ray with a known energy of 2.2 MeV.

Calculate the resulting loss in mass of a sulphur ion in u and confirm that this value could be determined by the Penning Trap technique.

(4)

$2.2 \times 10^{6} \times 1.6 \times 10^{-19} = 3.52 \times 10^{-13}$ J

$3.52 \times 10^{-13} = \Delta m \times c^2$

$\Delta m = 3.911 \times 10^{-30}$ kg

$= 2.36 \times 10^{-3}$ u

2.36×10^{-3} u $> 1 \times 10^{-5}$ u therefore the penning trap can measure it.

(Total for Question 17 = 13 marks)

ResultsPlus

Examiner Comments

An answer that scores full marks, not seen very often.

(ii) This device is known as a Penning Trap. It can be used to determine the mass of an ion to an accuracy of 3 parts in 10 million.

Confirm that the mass of a sulphur ion can be measured to the nearest 0.00001u.

mass of sulphur ion = 32.0645u

(2)

$\frac{3}{10000000}$ = 0.0000003, therefore as the penning trap can be used to determine the mass to an accuracy of 0.0000003, 0.00001 u can be measured.

(iii) Under certain conditions nuclei of sulphur emit a gamma ray with a known energy of 2.2 MeV.

Calculate the resulting loss in mass of a sulphur ion in u and confirm that this value could be determined by the Penning Trap technique.

(4)

$2.2\text{ MeV} = (2.2 \times 10^{6}) \times (1.60 \times 10^{-19})$

$= 3.52 \times 10^{-13}\text{ J}$

$\Delta E = \Delta m c^2 \qquad \Delta m = \frac{\Delta E}{c^2} = \frac{3.52 \times 10^{-13}}{(3 \times 10^{8})^2}$

$= 3.91 \times 10^{-30}\text{ kg}$

$1u = 1.66 \times 10^{-27}\text{ kg}$

$3.91 \times 10^{-30}\text{ kg} = 2.36 \times 10^{-3}\text{ u}$

(Total for Question 17 = 13 marks)

this value could be determined by the Penning Trap technique as it can be measured to the nearest 0.00001u.

ResultsPlus

Examiner Comments

A typical attempt at (ii) scores 0 and an excellent answer to (iii) scores 4. Units are only required at the end but this is a model answer showing all of the steps clearly and including the units at each stage.

ResultsPlus

Examiner Tip

Examiners will always try to follow the workings but random numbers with no symbols or words can be hard to follow so always try to set the work out clearly.

(ii) This device is known as a Penning Trap. It can be used to determine the mass of an ion to an accuracy of 3 parts in 10 million.

Confirm that the mass of a sulphur ion can be measured to the nearest 0.00001u.

mass of sulphur ion = 32.0645u

(2)

32.0645 can either be 32.06449u

or 32.06451u

therefore we can measure it to the nearest 0.00001u

(iii) Under certain conditions nuclei of sulphur emit a gamma ray with a known energy of 2.2 MeV.

Calculate the resulting loss in mass of a sulphur ion in u and confirm that this value could be determined by the Penning Trap technique.

(4)

2.2MeV = $(2.2 \times 10^{6}) \times (1.6 \times 10^{-19})$ kg

= ~~3.52 × 10⁻¹³ kg~~ ~~1.375 × 10⁻²⁶ kg~~ 3.52×10^{-13} kg

= ~~$\frac{3.52 \times 10^{-13}}{1.66 \times 10^{-27}}$~~ u

= ~~2.12 × 10¹⁴ u~~ $3.52 \times 10^{-13} \times 1.66 \times 10^{-27}$

~~32.0645 - 2.12 × 10¹⁴~~ $= 5.8432 \times 10^{-40}$

$32.0645 - 5.8432 \times 10^{-40} = 32.0645$u

(Total for Question 17 = 13 marks)

ResultsPlus

Examiner Comments

Another example of an incorrect attempt at (ii).

In (iii) candidate thinks that multiplying by e gives a mass in kg so misses out the dividing by c^2 step and then goes on to multiply the u conversion factor instead of dividing.

A common error was then to think that a subtraction had to be done showing a lack of understanding of the situation.

Question 18 (a)

Only about half of the candidates scored this mark. There were too many vague answers about keeping the time period constant without specifying what they meant by the time period. Candidates who tried to answer in terms of the alternating supply usually wrote about the a.c. current instead of the alternating p.d.

18 Evidence for a charm quark was discovered in 1974 at the linear accelerator (linac) at Stanford University.

(a) Why do the tubes of a linac become progressively longer down its length?

(1)

as the speed of the particles increase but they need the time period to stay constant.

ResultsPlus
Examiner Comments

Too vague an answer.

18 Evidence for a charm quark was discovered in 1974 at the linear accelerator (linac) at Stanford University.

(a) Why do the tubes of a linac become progressively longer down its length?

(1)

The further down its length the faster the particle will be moving so it needs to be longer so that the field can act for longer to accelerate it.

ResultsPlus
Examiner Comments

No credit for saying what is meant by acceleration and answer implies a longer time as well.

18 Evidence for a charm quark was discovered in 1974 at the linear accelerator (linac) at Stanford University.

(a) Why do the tubes of a linac become progressively longer down its length?

(1)

Due to the particle having more kinetic energy, the time within the tube must be at a certain frequency, hence needing them to be longer at faster speeds.

ResultsPlus

Examiner Comments

Another confused answer.

ResultsPlus

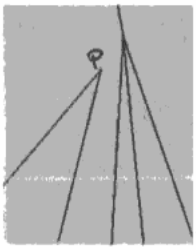
Examiner Tip

Read what has been written. Does it make sense?

Question 18 (b) (i-ii)

Most candidates were able to identify the correct position of the decay but those who got this wrong were not able to score any marks in this section. The answers that were needed here had to refer to the tracks (the use of the word track or trail was needed at least once). Candidates had been told that two particles had been produced so an answer that merely referred to the particles moving in opposite directions without reference to the tracks did not score the mark.

(b) This image shows the decay of a D^0 meson into a positively charged kaon and a negatively charged pion.



(i) Mark on the image the point P at which this decay occurs.

(1)

(ii) Give **two** reasons for choosing this point.

(2)

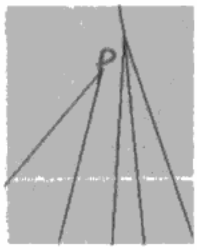
There is no ionisation before the decay as the meson consists on a quark and an antiquark so it will have no charge. After the decay there are two trails of ionisation which shows that both decayed particles had a positive or negative charge.

ResultsPlus

Examiner Comments

This answer does not say that the implication of no ionisation is no trail, but does go on to refer to two trails for the second mark.

(b) This image shows the decay of a D^0 meson into a positively charged kaon and a negatively charged pion.



(i) Mark on the image the point P at which this decay occurs.

(1)

(ii) Give **two** reasons for choosing this point.

(2)

The D° is no charge so there will be no track until decay. The kaon and the pion have the ~~same~~ opposite ~~masses~~ charge thus the tracks will be in opposite direction.

ResultsPlus

Examiner Comments

This gets the first mark for no track before the decay but there is no identification of two paths after decay.

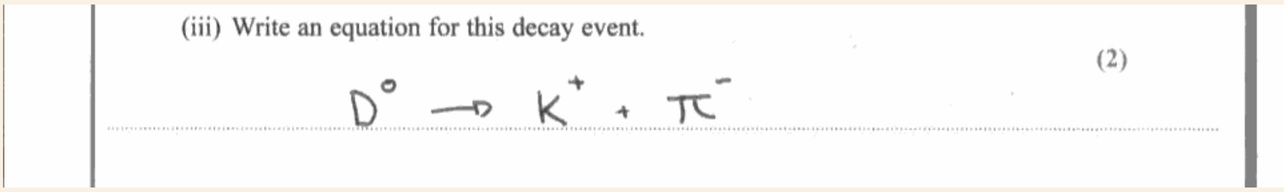
ResultsPlus

Examiner Tip

Don't just repeat what is in the question. At P there are two tracks, therefore that is where the decay must be.

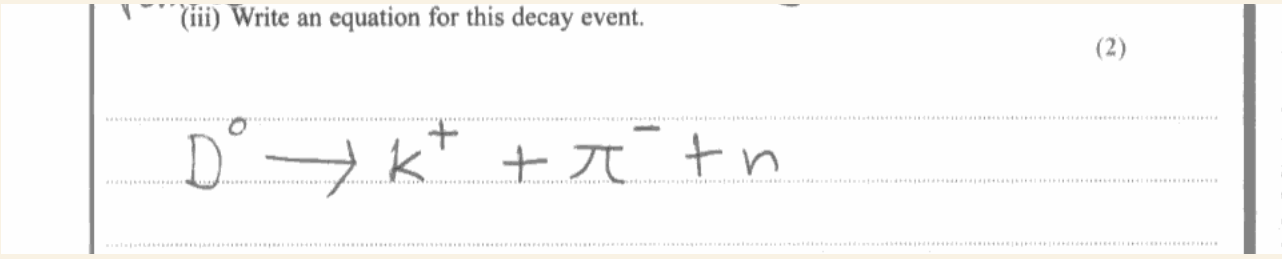
Question 18 (b) (iii)

Candidates are expected to know the symbols of frequently seen particles such as the kaon and pi and that the convention is that charge is shown on the top right side of the symbol. Over 60% of candidates did score both of these marks but this is basic factual recall that more candidates should be capable of gaining the marks for.


(iii) Write an equation for this decay event. (2)

$D^0 \rightarrow K^+ + \pi^-$

ResultsPlus
Examiner Comments
Perfet answer, scores both marks.


(iii) Write an equation for this decay event. (2)

$D^0 \rightarrow K^+ + \pi^- + n$

ResultsPlus
Examiner Comments
An extra neutron has been added.

ResultsPlus
Examiner Tip
Read the question carefully. Don't add extra particles unless the question says there is one.


(iii) Write an equation for this decay event. (2)

$D^0 \rightarrow {}^{+1}K^{+} + {}^{-1}\pi^{-}$

ResultsPlus
Examiner Comments
This scored one mark for correct symbols but lost the charge mark.

Question 18 (b) (iv)

Only the most able candidates scored 5 or 6 marks for this section. A large percentage of candidates scored three marks for stating the conservation laws but some lost marks by trying to apply rules such as lepton number and strangeness. The question asked how the laws applied to the specific decay and so merely stating and describing the law was not sufficient. The actual particles had to be referred to. A lot of candidates did score the second mark for conservation of charge but candidates must ensure that the symbols -1 and +1 are used. The second momentum mark was often lost because the candidates assumed that the initial momentum was zero. Candidates were allowed to state energy or mass or mass/energy as conservation but they needed to then be consistent with their application. Quite a few incorrect statements were made relating to mass and energy.

*(iv) State and discuss how three conservation laws apply to this decay event.

(6)

Charge is conserved as the net charge before of the D^0 particle (0) equals the net charge afterwards of the K^+ and π^- particles. (1 -1 =0)

Energy must be conserved as the total mass energy of the D^0 particle before must ~~equal~~s the total energy, mass and kinetic, of the K^+ and π^- particles afterwards.

Momentum must also be conserved as the two daughter particles must move on paths whose net vector momentum is the same as the momentum of the D^0 particle before.

ResultsPlus
Examiner Comments

This scores 5. It loses the mark for the missing + in the charge statement.

ResultsPlus
Examiner Tip

Read the question. The particles involved are specified so this answer scores well.

*(iv) State and discuss how three conservation laws apply to this decay event.

(6)

Conservation of charge has occured as the two resulting particles have the same charge put together (neutral charge) as the initial particle. The conservation of ~~mass also applies as~~ energy also applies as the total amount of energy is constant. Conservation of momentum also applies as the total momentum ~~with~~ of the particles is constant. This is shown as the two resultant particles travel in different directions.

ResultsPlus

Examiner Comments

An often seen answer that scores 3 marks for stating the conservation laws but does not apply them to the specific decay.

Question 18 (c) (i)

78% of candidates got this right.

Question 18 (c) (ii)

71% of candidates got this right. Most of those who didn't were trying to do a three quark combination.

This scored one mark for correct symbols but lost the charge mark.

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