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Examiners' Report
June 2025

GCSE Combined Science 1SC0 1PH

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June 2025

Publications Code 1SC0_1PH_2506_ER

Introduction

Questions were set to test candidates' knowledge, application and understanding from the six Physics topics in the Paper 5 section of Combined Science specification:

- Topic 1 – Key concepts of physics.
- Topic 2 – Motion and Forces.
- Topic 3 – Conservation of energy.
- Topic 4 – Waves.
- Topic 5 – Light and the electromagnetic spectrum.
- Topic 6 – Radioactivity.

It was intended that the examination paper would allow every candidate to show what they knew, understood and were able to do. Within the question paper, a variety of question types were included, such as objective questions, short answer questions worth one or two marks each and longer questions worth three or four marks each. Some questions were designed to target candidates' knowledge and understanding of practical work. This included assessing their fundamental knowledge of practicals specified in the specification; specifically, the refraction of light through a rectangular glass block and the investigation of waves using a ripple tank. There was also one extended open response question on radioactivity, worth six marks.

Although the specification required candidates to recall certain equations, a full list of all relevant Physics equations was also provided in a separate booklet as an appendix to the examination paper. Therefore, the assessment of candidates' mathematical skills involved selection of the relevant equations and became more demanding as the paper progressed with some questions requiring two or more steps to arrive at a correct answer.

Successful candidates:

- were well-acquainted with the content of the specification.
- had been engaged with practical work during their course.
- were competent in quantitative work, especially in being able to rearrange equations and use numbers in standard form.
- recognised key command words such as "describe" and "explain" and constructed their responses accordingly.
- were willing to apply physics principles to the novel situations presented to them.

Less successful candidates:

- had gaps in their knowledge of the topics of this paper.
- struggled to demonstrate procedural knowledge relating to their practical work.
- could recall important concepts such as Newton's 3rd law but were uncertain about how it applied.
- failed to set out calculations in a logical way that could be easily followed by the examiner.
- did not focus sufficiently on what the question was asking.

Overall, this exam gave ample opportunity for candidates to display their knowledge and understanding at grades 4-9.

Candidates have continued to do well with most calculation questions, although many didn't cope well with the units involved, which included the prefixes kilo and nano.

The standard of answers on practical questions was variable with some candidates showing good procedural knowledge, whilst for others there was difficulty in clearly describing the necessary steps. Based on their performance on this paper, candidates should make the most of opportunities afforded in school laboratories where they can become acquainted with practical work from the specification. This concerns both core practicals and the suggested practicals. It would benefit candidates to always question 'What is the purpose of this experiment?' making sure they are clear in their minds about it.

Question 1(a)i

Most candidates successfully identified the resultant force as being the force that accelerated the ball. After substituting into the equation given, they could rearrange the equation and evaluate the acceleration as 3.68 m/s2. Note that the mark scheme shows a correct answer of 3.7. This is because the values of mass and force were given to 2 significant figures. Therefore, the answer should be to the same number of significant figures. However, in most cases, unless the question specifies the number of significant figures required, examiners will give credit for an answer that would be displayed on a calculator.

Some candidates found difficulty in identifying the force that accelerated the beach ball and rearranging the equation given.

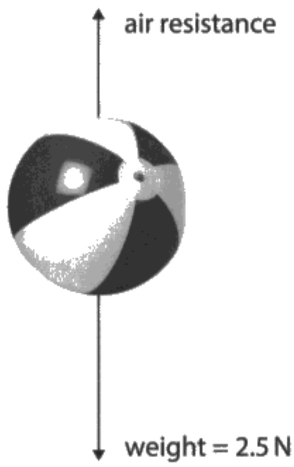
Because this was the first question on the paper and targeted at grade 4-5, candidates could gain partial credit for successfully rearranging the equation but using the incorrect force of 2.5N; which is the weight of the ball rather than the resultant downward force.

This approach is not necessarily adopted in later parts of the exam paper where higher grade responses are expected.

Answer ALL questions. Write your answers in the spaces provided.

Some questions must be answered with a cross in one of the four boxes ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 (a) Figure 1 shows the two forces acting on a beach ball as it falls through the air.



(Source: © Stepan Bormotov/Shutterstock)

Figure 1

The resultant of these two forces is 0.92 N downwards.

(i) The mass of the beach ball is 0.25 kg.

Calculate the acceleration of the beach ball as it falls.

Use the equation

$$F = m \times a$$

$F = 0.92N$ $a =$ **(3)**

$m = 0.25$

$\frac{F}{m} = a$

$\frac{0.92}{0.25} = a$

acceleration = 3.68 m/s²

ResultsPlus Examiner Comments

A well laid out answer. The accelerating force (0.92 N) has been clearly identified. The substitution and rearrangement are correct and the final evaluation gives the right answer. The examiner had no hesitation in awarding the full 3 marks.

$F = m \times a$

$0.92 = 0.25 \times a$

(3)

$a = \frac{0.25}{0.92}$

acceleration = 0.271 m/s^2

ResultsPlus
Examiner Comments

Because the candidate had written the values immediately below the equation the examiner could see that the correct force (0.92 N) had been selected. The rearrangement was wrong, however, and so the evaluation was incorrect. It scored 1 out of a possible 2 marks.

Answer ALL questions. Write your answers in the spaces provided.

Some questions must be answered with a cross in one of the four boxes ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

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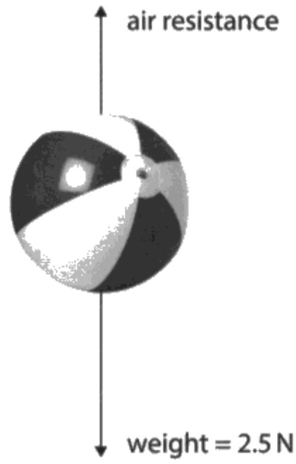


(Source: © Stepan Bormotov/Shutterstock)

Figure 1

The resultant of these two forces is 0.92 N downwards.

(i) The mass of the beach ball is 0.25 kg.

Calculate the acceleration of the beach ball as it falls.

Use the equation

$$F = m \times a$$

$2.5 = 0.25 \times a$

$\frac{2.5}{0.25} = a$

$10 = a$

(3)

acceleration = 10 m/s²

ResultsPlus
Examiner Comments

The candidate has chosen to use the wrong force. 2.5 N is the weight of the ball and not the resultant force (0.92 N). Nevertheless, the equation has been correctly rearranged and the evaluation is consistent with this. The examiner allowed this initial error to be carried forward and so could award 2 marks out of the possible 3.

Question 1(b)ii

Candidates could usually extend the given line up to h=0.9m and read the corresponding force of 3.1N.

Question 1(b)iii

Candidates usually drew a triangle on the graph to help them find the gradient of 3.9 N/m. Examiners gave some tolerance and allowed values between 3.8 and 4.0. Answers with a value outside this range were usually because the drawn triangle was too small to allow precise readings. They could still score a mark for showing the method, however.

The students then measure values of the force, F, for several different values of h, the height of the runway.

Figure 3 is a graph of F against h.

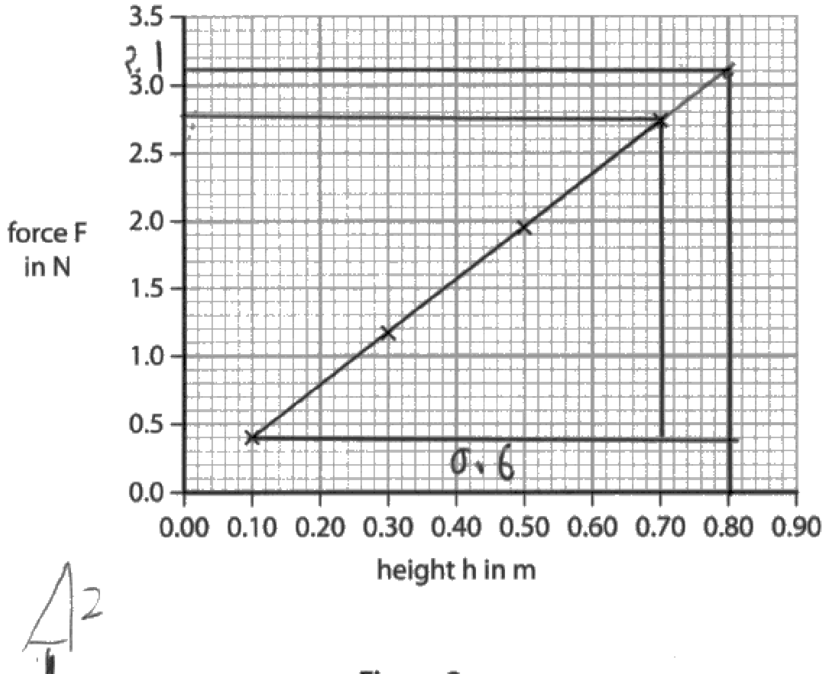


Figure 3

(ii) Use the graph in Figure 3 to determine the value of F when h = 0.80 m.

(2)

F = 3.1 N

(iii) Determine the gradient of the graph in Figure 3.

(2)

~~3.1 − 0.4 = 2.7~~

~~0.1 − 0.1 = 0.7~~

2.75 − 0.4 = 2.35

0.7 − 0.1 = 0.6

$\frac{2.35}{0.6} = 3.91\dot{6} = 3.92$ (2dp)

gradient = 3.92 (2dp) N/m

(Total for Question 1 = 9 marks)

ResultsPlus
Examiner Comments

A triangle has been clearly drawn and so scores one mark. The height and width of this triangle has been found and, from those values, the gradient has been correctly calculated. It scores the full 2 marks.

The students then measure values of the force, F, for several different values of h, the height of the runway.

Figure 3 is a graph of F against h.

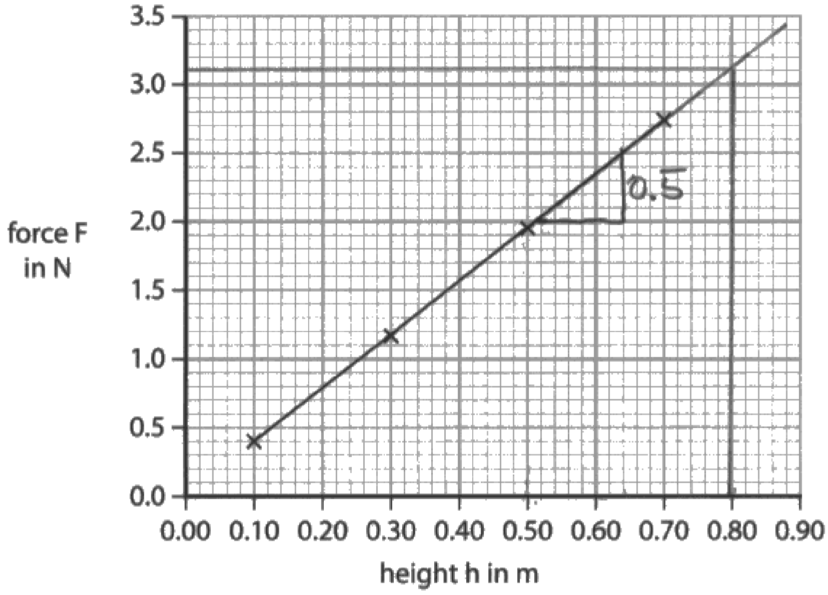


Figure 3

(ii) Use the graph in Figure 3 to determine the value of F when h = 0.80 m.

(2)

F = 3.1 N

(iii) Determine the gradient of the graph in Figure 3.

(2)

64 −0.52 0.12 $\frac{\Delta y}{\Delta x}$

$$\begin{array}{r} 64 \\ -52 \\ \hline 12 \end{array}$$

$\frac{0.5}{0.12} = 4.1\dot{6}$

gradient = 4.2 N/m

(Total for Question 1 = 9 marks)

ResultsPlus
Examiner Comments

A triangle has been drawn for one mark. However, this is too small for the candidate to be able to make precise readings from the graph and as a result the calculated value is out of the acceptable range. It scores 1 out of a possible 2 marks.

ResultsPlus
Examiner Tip

When finding the gradient of a graph try to use as much of the graph as you can. This will make it easier to find a precise value.

Question 2(a)iii

This question tested candidates' recall of a core practical that investigated waves, in this case the determination of wave speed. Two methods were possible. A wave crest could be timed over a known distance and then the equation wave speed = distance ÷ time could be used. An alternative method could be to use the equation wave speed = wavelength x frequency. Since the wavelength had already been determined in the previous part, candidates just needed to describe how to determine the frequency by counting the number of wave crests that passed a point in a given amount of time.

Candidates could usually show either of the acceptable equations to use. Descriptions of measurement of distance and time were generally clearer than descriptions of counting wave crests.

(iii) The water wave shown in Figure 4 is generated in a large tank.

A student observes the wave.

Describe how the student could determine the wave speed of the wave.

(2)

wavespeed = ~~wavelength x~~ distance ÷ time

measure the distance of the wave using a ruler

measure the time of the wave using a stopwatch

do the distance/time to get the wavespeed.

ResultsPlus
Examiner Comments

A suitable equation to use has been selected for one mark. The measurement of the relevant distance and time is missing, however. 1 mark out of a possible 2.

one student can use a stopwatch and measure the time it takes for the wave to travel through the whole tank, then measure the length of the tank and use the equation wavespeed = distance ÷ time

ResultsPlus
Examiner Comments

There is a clear description of timing a wave (crest) over a known distance for one mark. A suitable equation has been selected for the second mark. It scores 2 out of a possible 2 marks.

the wavespeed is always inversely proportional to the frequency, you could use equation speed = frequency x wave length

ResultsPlus
Examiner Comments

A suitable equation has been selected for one mark. There is no attempt to describe how to measure frequency and so no further marks can be awarded. It scores 1 out of possible 2 marks.

They could count ~~the~~ how many waves go past a point in 1 minute, they should then divide it by 60 to get the wave speed.

ResultsPlus
Examiner Comments

This starts with an acceptable description of how to determine the frequency. However, it continues with an incorrect statement about how to determine speed. It scores 1 mark out of a possible 2.

Question 2(b)i

Candidates could usually recall an example of a transverse wave and electromagnetic waves (with light or radio waves being the most common). The most frequently incorrect answer was sound.

Question 2(b)ii

Candidates often struggled to give a clear description of the rock being moved by a transverse wave. Examiners were looking for horizontal vibrations or oscillations perpendicular to the (vertical) direction of the wave.

Many candidates had the idea of vibrations (although often described in terms of the rock shaking) but either wrote that this was an up and down motion or failed to specify the direction at all.

Many candidates drew on the diagram, but these additions were rarely clear enough to support their description.

It was quite common to read answers concerning a possible eventual result of the earthquake such as the rock breaking. Such results would not necessarily occur, and examiners ignored these suggestions.

Question 2(b)iii

This question required careful reading in order to be answered correctly. Candidates needed to refer back to the diagram to be sure that they were calculating the correct distance.

Many candidates could use the equation distance = speed x time to calculate the distance from Earth's surface to the rock and gain at least 1 mark.

(iii) The wave from **X** reaches **L** 3.8 seconds after it passes through **R**.

The speed of the wave is 4500 m/s.

Calculate the distance between **X** and **R**.

d

ws t

(2)

$$\text{wavespeed} = \frac{\text{distance}}{\text{time}}$$

$$4500 = \frac{x}{3.8} \qquad 4500 \times 3.8 = 17{,}100$$

distance = 17,100 m

(Total for Question 2 = 9 marks)

ResultsPlus
Examiner Comments

Correct calculation of distance from R to L scores 1 mark. There was no attempt to find the distance from X to R and so it did not score a second mark. 1 mark out of a possible 2.

Fewer candidates referred back to the diagram to use the given distance between the Earth's surface and X (where the earthquake happened) to determine the distance between the rock and X to score the 2nd mark.

(iii) The wave from **X** reaches **L** 3.8 seconds after it passes through **R**.

The speed of the wave is 4500 m / s.

Calculate the distance between **X** and **R**.

(2)

distance travelled = average speed x time

d = s x t

d = 4500m/s x 3.8 = 17 100m = 17.1km

20km - 17.1 = 2.9km

= 2900m

distance = 2900 m

(Total for Question 2 = 9 marks)

ResultsPlus
Examiner Comments

The distance from R to L is correctly calculated for one mark. The distance between X and R is then found by subtracting the previous value from 20km for the second mark. It scores the full 2 marks.

A few candidates chose an alternative method. They calculated the time for a wave to travel from X to the Earth's surface (4.4s) and then, using the time given for the wave to travel from the rock to the Earth's surface (3.8s), calculated the time taken for the wave to travel from X to the rock. This can then be used, together with the speed of the wave, to determine the distance from X to the rock.

(2)

$\cancel{\frac{4500}{3.8}} \div$ $\frac{20{,}000\text{ m}}{4500} = 4.\dot{4}$

$4.\dot{4} - 3.8 = 0.6\dot{4}$

$4500 \times 0.6\dot{4} = 2900$

distance = 2900 m

(Total for Question 2 = 9 marks)

ResultsPlus
Examiner Comments

Correct calculation of time (4.4 s) from X to L for one mark. Correct calculation of distance (from X to R) using the difference in time for the second mark. Total 2 out of 2 marks.

Question 3(a)

This question required candidates to describe an investigation that produced a ray diagram using a ray box and a glass block.

It was common to read of a suitable starting point; draw round the block and then shine a ray on the block. Clear descriptions of marking the path of the ray (for example with crosses on the paper underneath) were less common and simply “draw the rays” was often seen. Very few candidates mentioned connecting the entry and exit points of the ray after the block was removed.

3 (a) When light travels from air into glass, it is refracted.

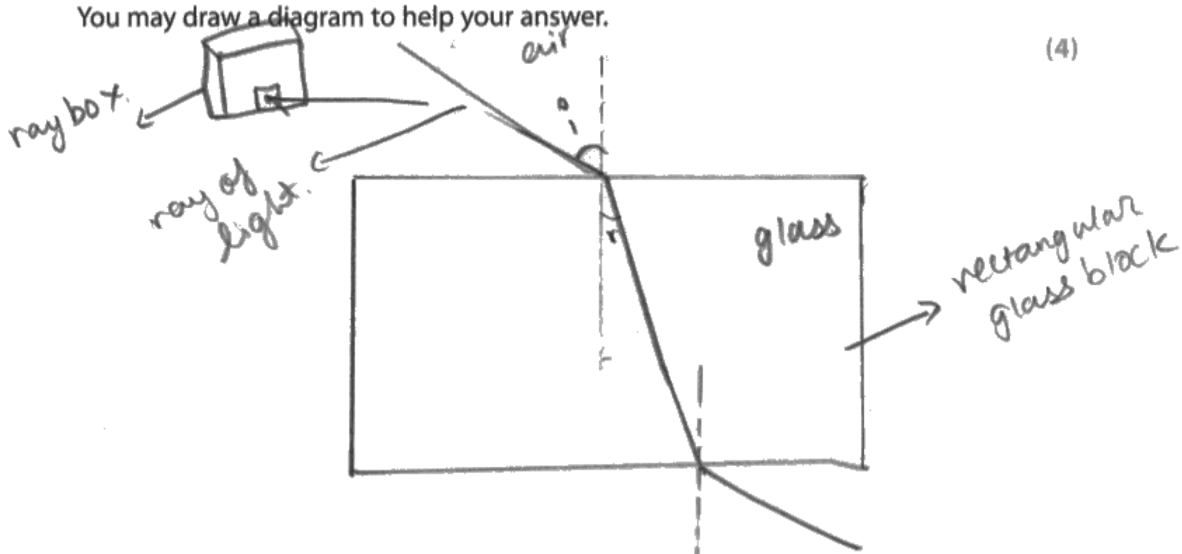
To investigate this, a student has a rectangular glass block and a ray box.

The ray box produces a ray of light.

Describe how the student should use the glass block and ray box to produce a refracted ray and mark its position.

You may draw a diagram to help your answer.

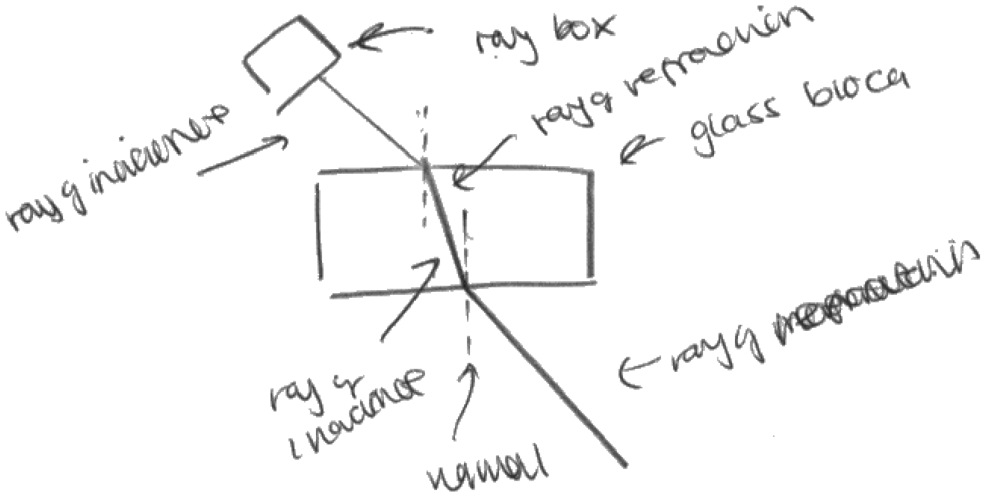
(4)



Set up the apparatus show above. A ray box which produce light should be placed in front of glass block and underneath the glass block there is a paper. Pass the light int the rectangular glass block. Mark or draw the ray of incidence (i) which is ray outside the box. Inside the box of glass has a refracted ray as it changes it speed and direction as it travels from one medium to another. Mark or draw that ray an angle on the paper and also draw normal which is perpendiclar to rectangular box.

ResultsPlus
Examiner Comments

There is a mark for either the labelled diagram or for the statement " ... ray box... placed in front of the glass block ". There is another mark for marking/drawing the ray of incidence. There is no further rewardable content. It scores 2 marks out of a possible 4.



(4)

* draw around a glass block
* shine the ray of light on the glass block using ray box
* mark where the light enters the block and leaves the block.
* join the 2 points, this is the angle of refraction.

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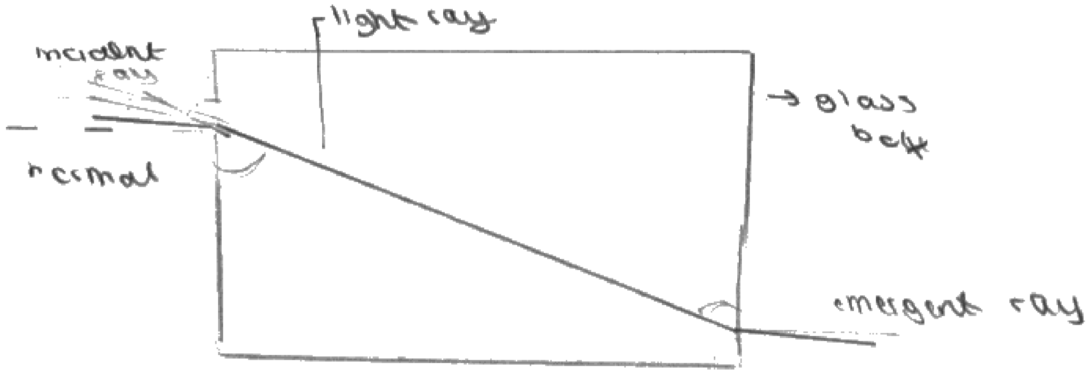
Examiner Comments

This is a short answer that describes the method in a few lines. It mentions all of the available mark points; how to send the ray into block, draw round the block, how to mark the rays and how to join them up. It scores the full 4 marks.

Many candidates seemed to read the question in terms of describing or showing the refraction of light rather than describing how to use the equipment.



- use light box + turn on
- refracts when in glass box
- bend towards normal → speeds up.

ResultsPlus
Examiner Comments

This could have scored one mark if the diagram had been fully labelled but there is no ray box shown with a label. The rest of the response does not describe a method. It scored 0 marks.

ResultsPlus
Examiner Tip

If you draw a diagram, make sure that you include all the necessary labels.

Question 3(b)i

Most candidates analysed the data in the table to conclude that the wavelength increases when light goes from glass to air.

Question 3(b)ii

Most candidates analysed the data in the table to conclude that the frequency does not change when light goes from glass into air.

Question 3(b)iii

Two approaches to this calculation were possible. The speed in glass could be found and then the difference between this speed and the given speed in air would produce the answer. Most candidates adopted this approach. The most common error was handling the powers of ten involved in frequency and converting 350 nanometres into metres. Examiners would give 1 mark for the use of the equation speed = frequency x wavelength even if incorrect powers of ten were used. A second mark was awarded if the evaluation was fully correct (2.2 x 108 m/s).

The third mark was for finding the difference between this speed and the speed in air. This mark could be awarded even if the speed in glass was incorrect.

Examiners saw many fully correct answers but most scored 2 out 3 marks.

(iii) The speed of blue light in air is 3.0×10^8 m/s.

Calculate the change in the speed of blue light when it travels from air into glass.

Use the equation

$$v = f \times \lambda$$

350 nm → 3.5×10^{-7} m

(3)

m
mm
μm
nm

blue light speed in glass = f × λ

$= 6.4 \times 10^{14} \times 3.5 \times 10^{-7}$

= 224000000

2.24×10^8

$3.0 \times 10^8 - 2.24 \times 10^8 = 76\,000\,000$

7.6×10^7

change in speed = 7.6×10^7 m/s

(Total for Question 3 = 9 marks)

ResultsPlus
Examiner Comments

A nicely laid out answer. The candidate has correctly converted nanometres to metres before substituting and evaluating the speed in glass. This was then correctly subtracted from the speed of light in air to arrive at the correct answer. It scores the full 3 marks.

$$v = f \times \lambda$$
$$= 6.4 \times 10^{14} \times 350$$
$$= 2.24 \times 10^{17}$$

$$2.24 \times 10^{17} - 3.0 \times 10^{8}$$
$$= \cancel{2.3} \; 2.2 \times 10^{17}$$

change in speed = 2.2×10^17 m/s

(Total for Question 3 = 9 marks)

ResultsPlus
Examiner Comments

There is a good attempt to find the speed in glass, but the wavelength has been kept in nanometres. This produces a speed which is much too large. Nevertheless, the candidate has found the difference by subtracting the speed in air from (the much larger) calculated value of the speed in glass. It scores 2 marks out of a possible 3.

ResultsPlus
Examiner Tip

Check the units carefully and know how to handle prefixes such as n (nano) as well as m (milli) and μ (micro).

An alternative approach was to calculate the change in wavelength as it travelled from air to glass and then multiply this change by the frequency to find the change in speed. This was possibly a simpler approach but did require the understanding that the frequency did not change. Examiners saw much fewer examples of this approach. Once again, partial credit was given for use of suitable equations with a power of ten error.

$v = f \times \lambda$

$6.4 \times 10^{14} - \underbrace{6.4 \times 10^{14}}_{\text{still use number}} = 0$

(3)

$470 \times 10^{-9} = 4.7 \times 10^{-7}$

$350 \times 10^{-9} = \cancel{4.7}\ 3.5 \times 10^{-7}$

$4.7 \times 10^{-7} - 3.5 \times 10^{-7} = 1.2 \times 10^{-7}$

$1.2 \times 10^{-7} \times 6.4 \times 10^{14} = 76800000$

7.68×10^{7}

$300,300,000 - 224,000,000 = 76,800,000 \rightarrow 7.68 \times 10^{7}$

change in speed = 7.68×10^{7} m/s

(Total for Question 3 = 9 marks)

ResultsPlus
Examiner Comments

This starts out with a correct conversion of the wavelengths in air and glass from nm to m. The change in wavelength is then multiplied by the frequency to give the change in speed. It scores the full 3 marks.

$v = 3.0 \times 10^8 \times 470 - 350$

120

$v = 3.6 \times 10^{10}.$

change in speed = 3.6×10^{10} m/s

(Total for Question 3 = 9 marks)

ResultsPlus
Examiner Comments

The working shows an attempt to find the change in wavelength (even though they are both in nm). It can score one mark. There was no further successful progress, however. It scores 1 out of 3 possible marks.

Question 4(a)i

This question required candidates to extract the relevant information from the values given to calculate h using the equation for change in GPE. Most candidates rearranged the equation correctly and substituted the correct given values into the rearranged equation for 1 mark.

The 2nd mark was for a correct evaluation. In those few cases, where this mark was lost, either a zero was lost in the working or the calculator was incorrectly used.

4 (a) Figure 7 shows a skier sliding down a slope.

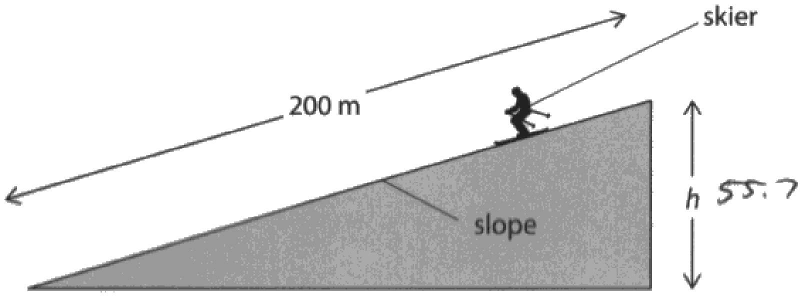


Figure 7

(i) The gravitational potential energy of the skier decreases by 39 000 J between the top and the bottom of the slope.

The mass of the skier is 70 kg.

Calculate the height, *h*, of the slope.

The value of g is 10 N/kg.

Use the equation

$$\Delta GPE = m \times g \times h$$

(2)

$\frac{\Delta GPE}{m \times g} = h$

$\frac{39000}{70 \times 10} = 55.71428571$

55.7

$h =$ 55.7 m

ResultsPlus
Examiner Comments

A well laid out answer with the correct value given. 2 out of 2 marks.

Avoidable mistakes were often made.

The mass of the skier is 70 kg.

Calculate the height, h, of the slope.

The value of g is 10 N/kg.

Use the equation

$$\Delta GPE = m \times g \times h$$

(2)

$$\frac{\Delta GPE}{m \times g \times h}$$

$$h = \frac{\Delta GPE}{m \times g}$$

$$h = \frac{39000}{70 \times 10} \qquad h = \frac{3900}{700}$$

$$h = 5.571428571$$

$h =$ 5.57 m

ResultsPlus
Examiner Comments

This started out well and scored one mark for the rearrangement and substitution. Unfortunately, a zero got lost in the top line and the answer was 10 times too small. 1 mark out of 2.

Use the equation

$\Delta GPE = m \times g \times h$

(2)

GPE

m × g × h

$$\frac{39000}{70 \times 10} = 5571 \cdot 4$$

$h =$ 5571·4 m

ResultsPlus
Examiner Comments

The rearrangement and substitution were correct for one mark. In the evaluation, however, the candidate seemed to have used the calculator to divide 39000 by 70 and then multiply by 10 (rather than dividing again by 10). The final value was 100 times too big. 1 mark out of 2.

ResultsPlus
Examiner Tip

Make sure you know how to use your calculator to evaluate expressions with a multiplication on the bottom line.

Question 4(a)ii

This question required candidates to extract the relevant information from the diagram to calculate the acceleration of the skier along the slope. There were two possible approaches.

Candidates could select and use the equation v2-u2 = 2× a× x. The value of v was given as 27 m/s. The value of x is the distance along the slope (200 m) which can be found from the diagram. Many candidates confidently rearranged and evaluated to arrive at a value of 1.8 m/s2 for the full 3 marks. Those candidates who used the wrong value for x; usually taking the vertical height of 56 m previously calculated in part (i), could gain partial credit for 2 marks.

For this reason, examiners could see the answer to part (i) when marking part (ii).

4 (a) Figure 7 shows a skier sliding down a slope.

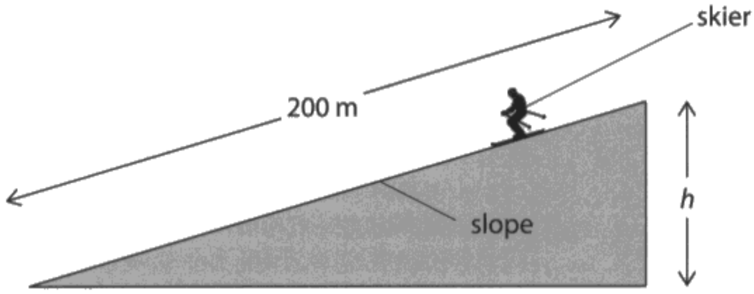


Figure 7

(i) The gravitational potential energy of the skier decreases by 39 000 J between the top and the bottom of the slope.

The mass of the skier is 70 kg.

Calculate the height, *h*, of the slope.

The value of g is 10 N/kg.

Use the equation

$$\Delta GPE = m \times g \times h$$

$39000 = 70 \times 10 \times h$

$55.71... = h$

(2)

$h =$ ~~56~~ 56 (2sf) m

(ii) The skier starts from rest at the top of the slope.

The velocity of the skier at the bottom of the slope is 27 m/s.

Using information from Figure 7, calculate the acceleration of the skier along the slope.

$v^2 - u^2 = 2 \times a \times x$

$27^2 - 0^2 = 2 \times a \times 200$

$729 = 400 \times a$

$1.82... = a$

(3)

acceleration = 1.8 (2sf) m/s²

ResultsPlus
Examiner Comments

A well laid out answer with the correct final value. It was pleasing to see a suitable number of significant figures on the answer line. It scores the full 3 marks.

$v^2 - u^2 = 2 \times a \times x$

$(27)^2 - (0)^2 = 2 \times A \times 200$

$729 = 2 \times A \times 200$

$-2 \qquad -2$

$727 = A \times 200$

$\div 200 \qquad \div 200$

$3.635 = A$

acceleration = 3.635 m/s^2

ResultsPlus
Examiner Comments

This started well with the selection of a suitable equation and substitution of the correct values to score one mark. However, the rearrangement process was incorrect and the final answer wrong. It scores 1 out of a possible 2 marks.

Another approach was to use a = (v-u) / t. This required the candidate to understand that t is calculated from the average speed (13.5 m/s) and not the final speed (27 m/s). Few candidates appreciated this and simply divided 200 by 27 and scored no marks.

(3)

acceleration = change in velocity ÷ time taken

3.645 = 27 ÷

time = $\frac{200}{27}$ = 7.407407407

acceleration = 3.645 m/s²

ResultsPlus
Examiner Comments

The candidate has chosen to use a different method. This would have worked if the average speed down the slope had been used rather than the final speed. Because the physics was incorrect from the start it scored 0 marks.

Question 4(a)iii

Energy dissipated can be determined by subtracting the kinetic energy at the bottom of the slope from the change in gravitational potential energy between the top and bottom of the slope and a statement such as this would score 2 marks. Although many candidates could write about subtraction of energies, their responses were often imprecise and scored only 1 of the 2 available marks.

Candidates would often discuss how or why energy is dissipated rather than how the amount could be determined.

(iii) When the skier slides from the top to the bottom of the slope, some energy is dissipated.

Explain how to determine the amount of energy dissipated.

(2)

the energy is dissipated because as the Skier gets lower to the ground, gravitational potential energy decreases and dissipates into kinetic energy, moving the skier down the slope.

ResultsPlus Examiner Comments

This typical response describes dissipation of energy but does not address how this can be measured. 0 marks scored.

Through friction which is transferred from the ski to the snow creating thermal energy from kinetic energy

ResultsPlus Examiner Comments

This answer tries to address why energy is dissipated but not how to determine the amount. 0 marks scored.

Stronger answers included the idea of subtracting amounts of energy, even if those two amounts were not clearly stated.

- total energy - useful energy = dissipated/wasted energy
- can be represented with a Sankey diagram

ResultsPlus
Examiner Comments

Here, the candidate has indicated the calculation of dissipated energy for one mark but has not described how it can be determined in the context of the question. 1 mark out of a possible 2.

A complete answer would mention the kinetic energy at the bottom of the slope and the change in gravitational potential energy of the skier between the top and bottom of the slope.

Calculate his GPE at the top of the slope then is kentic energy at the bottom of the slope, the take away the KE from the GPE

ResultsPlus
Examiner Comments

This answer clearly describes the two energies and how to use them. Although gravitational potential energy is not described as being a change between top and bottom but rather a value at the top, examiners would accept "at the top" in this context. 2 marks out of a possible 2.

Question 4(b)i

Candidates could often recall that velocity has magnitude and direction or that the direction of each athlete was changing and so score the mark.

Question 4(b)ii

In order to find the gradient at 2.5 s, candidates had to draw a tangent to the curve at this point. The gradient is then calculated from the gradient of this tangent. It was pleasing to see that many candidates tackled this confidently and gave an answer with a value in the acceptable range of 5.0 to 7.0. It was common, however, to see calculations based on just one point on the line and those responses could not score any marks.

(ii) The athletes start the race on a straight section of track.

Figure 9 shows a distance / time graph for one of the athletes.

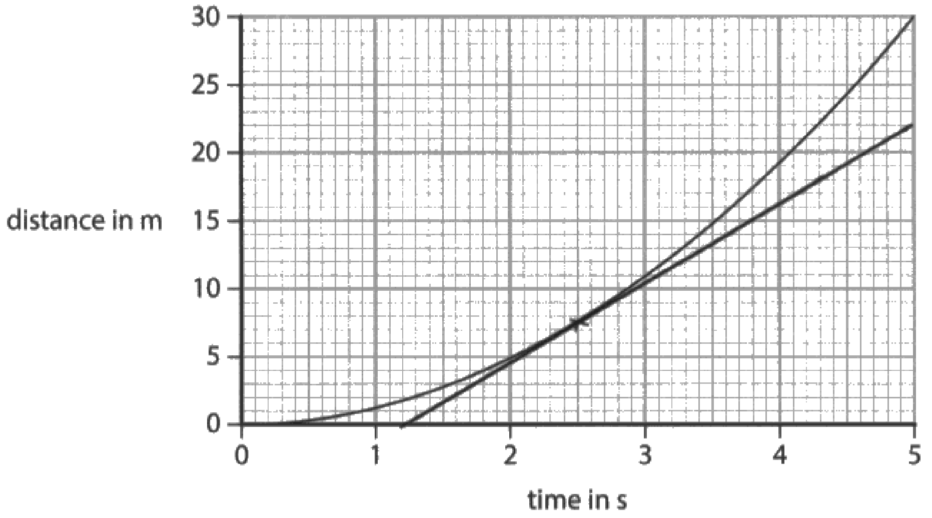


Figure 9

Determine the gradient of this graph at a time of 2.5 s.

(2)

$$\frac{\text{change in } y}{\text{change in } x}$$

$$\frac{22 - 6}{5 - 1.2} = 5.\cancel{8}79$$

gradient = 5.79 m/s

(Total for Question 4 = 10 marks)

ResultsPlus
Examiner Comments

A tangent was drawn at 2.5 s for one mark. The gradient of this tangent was correctly calculated to give a value in the acceptable range. Total 2 out of 2 marks.

$\frac{23}{1.3} = 15.33...$

$= 15$

gradient = 15.3 m/s

ResultsPlus
Examiner Comments

A tangent was drawn at 2.5 s for one mark. The calculation of the gradient was incorrect and scored no further marks. Total 1 out of a possible 2 marks.

$7.5 - 2.5 =$

gradient = 5 m/s

ResultsPlus
Examiner Comments

No tangent was drawn at 2.5 s. This meant that it was not possible to find the gradient of the graph at this point. Although there is a calculation with an answer in the acceptable range, this is not a calculation of gradient and so scored no marks. Total 0 out of a possible 3 marks.

Question 5(a)i-ii

Most candidates could select and apply the equation to calculate the momentum of the ball. There was less success in recalling the units of momentum.

Once again there were two possible approaches to calculating the duration of contact between the foot and the ball.

The most popular approach was to select and use the equation force = change in momentum / time. Because the value for momentum had to have been calculated in the previous part, examiners would give credit either for either using the correct value (15 kg m/s) or the value that had been previously calculated. One mark was awarded for showing that a suitable equation had been selected and a second mark for rearranging and evaluating to arrive at an answer of 0.0056 s.

5 (a) Figure 10 shows a footballer and a ball.

(Source: © GelgelNasution/Shutterstock)

Figure 10

The ball is stationary before it is kicked.

The [redacted] of the ball is [redacted].

The kick exerts a [redacted] on the ball.

The [redacted] of the ball just after it has been kicked is [redacted]s.

(i) [redacted] of the ball just after it has been kicked.

State the unit for momentum.

(3)

$p = m \times v$

$p = 0.43 \times 36$

$p = 15.48$

momentum = 15.48

unit Kg m/s

(ii) Calculate the amount of time that the footballer's kicking foot is in contact with the ball.

(2)

$F = \frac{mv - mu}{t}$

$2700 = \frac{15.48 - 0}{t}$

$2700 = \frac{15.48}{t}$

$\frac{15.48}{2700} = t = 0.0057$

time = 0.0057 s

ResultsPlus Examiner Comments

A nicely laid out answer. In part (ii) the working is clear, the answer is correct and the unit of momentum is given for the full 3 marks. Examiners would allow values from a calculator (such as 15.48) although it is best practice to always give your answer to the same number of significant figures as the values given in the question. So here, the best answer value is 15. In part (iii) clear working is shown leading to a correct answer that is rounded to 2 significant figures.

5 (a) Figure 10 shows a footballer and a ball.

(Source: © GelgelNasution/Shutterstock)

Figure 10

The ball is stationary before it is kicked.

The mass of the ball is 0.43 kg.

The kick exerts a force of 2700 N on the ball.

The velocity of the ball just after it has been kicked is 36 m / s.

(i) Calculate the momentum of the ball just after it has been kicked.

State the unit for momentum.

(3)

momentum = mass × velocity

$p = m \times v$

$= 0.43 \times 36$

$= 15.48$

momentum = 15.48

unit ~~Nm~~ N/s

(ii) Calculate the amount of time that the footballer's kicking foot is in contact with the ball.

(2)

$F = \frac{(mv - mu)}{t}$

$2700 = \frac{15.48}{t}$

$D = S \times T$

$F = \frac{D}{S}$

time = 41796 s

$t = 15.48 \times 2700$

$= 41796$

ResultsPlus
Examiner Comments

In part (ii) the calculation is correct but the unit is not. It scored 2 out of a possible 3 marks. In part (iii) a suitable equation was selected and the value from part (ii) was correctly substituted into that equation for one mark. The evaluation of time is incorrect however, probably because the rearrangement was not done correctly. It scored 1 out of a possible 2 marks.

An alternative method was to calculate the acceleration of the ball from force = mass x acceleration and then use this value for acceleration in the equation acceleration = change in velocity / time to calculate the time.

5 (a) Figure 10 shows a footballer and a ball.

(Source: © GelgelNasution/Shutterstock)

Figure 10

The ball is stationary before it is kicked.

The mass of the ball is 0.43 kg.

The kick exerts a force of 2700 N on the ball.

The velocity of the ball just after it has been kicked is 36 m / s.

(i) Calculate the momentum of the ball just after it has been kicked.

State the unit for momentum.

(3)

$0.43 \times 2700 = 1161$

momentum = 1161

unit kg m/s

(ii) Calculate the amount of time that the footballer's kicking foot is in contact with the ball.

(2)

$\frac{(v-u)}{a} = \frac{(36-0)}{} = 0.00573$

F=ma

$\frac{F}{m} = \frac{2700}{0.43} = 6279.1$

time = 0.0057 s

Results Plus
Examiner Comments

Although the calculation in part (ii) was incorrect, there was an independent mark for the correct units of momentum giving a score of 1 out of 3 marks. In part (iii), the acceleration was calculated using F/m to be 6279.1 (m/s2). This value was then used in the equation (v-u)/axt to correctly find the time of 0.00573. The candidate correctly rounded this to 2 significant figures in the answer line. This part scored the full 2 marks.

Question 5(a)iii

It was clear that more candidates could recall Newton's third law than could explain how it applied to a foot kicking a ball. A good response would quote the law and then describe the force from the ball on the foot being equal in size to the force of the foot on the ball but in the opposite direction.

In general, those candidates who stated the law in terms of pairs of forces (for example "*when a force acts on an object, another force of equal size but in the opposite direction acts on another object*") applied that law more clearly than those who simply wrote "*action and reaction are equal and opposite*".

Newton's third law was often stated in terms of *action and reaction are equal and opposite*. However, this seemed poorly understood. In particular the term *reaction* was often seen as a consequence of the force rather than another force in the opposite direction.

(iii) Explain how Newton's third law applies to the interaction between the kicking foot and the football.

(3)

Newton's third law states that with every action there is always an equal ~~or~~ and opposite reaction. The ball was stationary ~~unto~~ which was the action untill the footballer kicked the ball creating energy as the total momentum before a reaction is the same as total momentum after a reaction.

ResultsPlus
Examiner Comments

There is one mark for a correct statement of Newton's third law. However, the remainder of the response does not consider forces and scored no further marks.

Every action has an equal and opposite reaction.
This means how much force you put into kicking a ball will result in how far it will go.
The ball has air resistance keeping it down but gravity keeping it up which are the same but in different directions.
kicking foot how much force is put in is how much force is oppositley came out.

ResultsPlus
Examiner Comments

Here, the examiner could award one mark for the statement of Newton's third law. However, the remainder of the response seems to concern Newton's second law and also energy transfers. 1 mark out of 3 scored.

Candidates who gave Newton's third law in terms of a pair of forces often managed to apply it to this scenario.

Newtons third law states that when a force is applied to an objectect an equal and oppisit force is applied back. When the footballers foot hits the ball a force of 2700N wass applied to the ball, and the ball then applieed a force of 2700 N back onto the football player.

ResultsPlus
Examiner Comments

Newton's third law is clearly stated for 1 mark. The response goes on to consider the force exerted by the foot on the ball (ie the action) and the corresponding force exerted by the ball on the foot (ie the reaction). A nice answer that scored the full 3 marks.

Question 5(b)

This question required recall of the principle of conservation of momentum and then an explanation as to how this can be applied to the collision between two trolleys.

Similar to the previous question, many responses showed recall of the principle but fewer fully explained how this can be applied.

Examiners were looking for an explanation that linked conservation of momentum and the increase of mass of the system when the trolleys stick together. Then, since momentum = mass x velocity, an increase in mass must result in a decrease in velocity.

(b) Figure 11 shows a system consisting of two toy trolleys, **S** and **T**, on a straight, horizontal track.

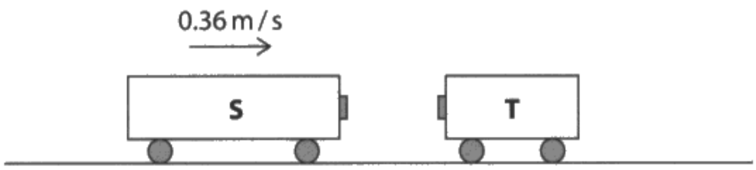


Figure 11

T is not moving.

S is moving with a velocity of 0.36 m/s towards **T**.

S collides with **T**.

The trolleys stick together and move off together.

With reference to the momentum of the system, explain why the velocity of the trolleys after the collision is less than the velocity of **S** before the collision.

(3)

The principle of conservation of momentum states that momentum before a reaction = momentum after. ~~Sa~~ Momentum is equal to the mass x velocity. Since the total mass of the system increase, as there are now two trolleys, the velocity must decrease in order to keep the momentum the same.

(Total for Question 5 = 11 marks)

ResultsPlus
Examiner Comments

This response gave a correct explanation that included all of the required points in a logical order. It scored the full 3 marks.

Although momentum was often correctly described as mass x velocity, the actual nature of momentum was often misunderstood. Many candidates seemed to confuse momentum with energy or force.

- momentum = mass x velocity therefor

$\frac{\text{momentum}}{\text{mass}}$ = velocity

- the momentum after the collision would dissipate into the surroundings while the mass would increase because now there are two trolleys
- smaller momentum and higher mass also decrease the velocity

(Total for Question 5 = 11 marks)

ResultsPlus
Examiner Comments

There is a mark for stating momentum = mass x velocity and another mark for realising that the mass of the moving components of the system had increased. However, this is not linked to the idea of conservation of momentum and so it scored 2 out of 3 marks.

· Momentum in a system is supposed to remain the same before and after a collision. However some of the energy that S has (kinetic) gets dissipated as sound energy into its environment as it collides with T. ~~Some energy is lost from the system but just used differently, so the energy stays the same but the velocity doesn't.~~ Also the trolley T will move backwards with a momentum that is equal to the difference before and after the collision - The sum of momentum of S and T is equal to before the collision.

(Total for Question 5 = 11 marks)

ResultsPlus
Examiner Comments

The principle of conservation of momentum is stated for 1 mark only. The remainder of the response shows confusion between momentum and energy.

- In any collision total momentum is always conserved.
- The longer the time it takes for momentum ~~to loss~~ the lower force exerted.
- Newtons 2nd law 2 accelerating objects hit against/collide transfer energy to the surroundings.
- so the velocity of the trolleys after collision is less than the velocity of s before collision is because it's energy has been disipated to surroundsing - so it has lost energy.

(Total for Question 5 = 11 marks)

ResultsPlus
Examiner Comments

This response starts with a correct summary of the principle of conservation of momentum for 1 mark only. However, it goes on to try to use Newton's second law and energy transfers. Examiners saw many similar responses that scored 1 out of a possible 3 marks.

Question 6(a)iii

This question required selection of the equation for kinetic energy and, after substituting the given values, to correctly handle the powers of ten and the squared term. This was often well answered with very many candidates giving the correct value.

(iii) The mass of a beta minus particle is 9.1×10^{-31} kg.

Calculate the kinetic energy of a beta minus particle moving with a speed of 3.8×10^{6} m/s.

(2)

Kinetic energy $= \frac{1}{2} \times$ mass $\times (\text{speed})^2$

$$KE = \frac{1}{2} \times 9.1 \times 10^{-31} \times (3.8 \times 10^{6})^2$$

$$KE = 6.57 \times 10^{-8}$$

$$= 6.6 \times 10^{-8}$$

kinetic energy = 6.6×10^{-8} J

ResultsPlus
Examiner Comments

A nicely laid out response that showed a correct substitution for one mark. It was pleasing to see that the calculated value of 6.57 was rounded down to 6.6. Unfortunately, the candidate made a mistake with the powers of ten to arrive at an answer of 6.6×10^{-8} rather than the correct answer of 6.6×10^{-18} so only 1 mark out of 2 was scored.

ResultsPlus
Examiner Tip

Practice calculations using powers of ten; especially when one value is squared.

Question 6(b)

This question required recall of the process of beta plus decay and was targeted at higher ability candidates. Examiners were looking for a description of a proton becoming a neutron (plus a positron). To their credit, many candidates knew that a proton was involved and scored at least one mark. Far fewer candidates correctly described the process correctly, however. It was common to see a description of beta decay with a neutron becoming a proton.

(b) Describe what happens in the nucleus of an atom when a beta plus particle is emitted.

(2)

proton turns to a neutron and a positron: $p \rightarrow n + e^+$

ResultsPlus
Examiner Comments

Reference to a proton scores one mark and a correct description of it turning into a neutron scores the second mark. Examiners would also accept the symbols p à n for 2 marks.

beta $^{0}_{+1}$ the nucleus of the atom loses / decays a neutron which is then turned into a proton. and a electron, hence why the mass number doesn't change.

ResultsPlus
Examiner Comments

There is one mark for a reference to protons but this answer describes beta (minus) decay rather than beta plus decay. It scored 1 mark only.

Question 6(c)

This question asked for a comparison of alpha and gamma radiation; both in terms of a description of the radiation and the effect on the nucleus of an atom when emitted.

Descriptions of alpha radiation could include that an alpha particle consists of 2 protons and 2 neutrons or a helium nucleus. When emitted, the atomic number of the nucleus decreases by 2 and the mass number decreases by 4 to become the nucleus of a different element.

Descriptions of gamma radiation could include that it is a high frequency electromagnetic wave and therefore has no charge or mass. When emitted by the nucleus there is no change in the atomic or mass number, but the nucleus does lose energy to become more stable.

In all cases, for either alpha or gamma, one correct fact about the nature or the effect on the nucleus was sufficient.

A Level 3 answer would include a description of at least one of radiation and the effect of the emission of that radiation from the nucleus together with either the effect or description of the other. Examiners saw many Level 3 answers.

*(c) Radioactive decay can produce gamma radiation and alpha radiation.

Compare the processes of gamma decay and alpha decay.

Your answer should include

- a description of both gamma radiation and alpha radiation
- the effect of each type of decay on the original nucleus.

(6)

Alpha

• Alpha radiation is composed of 2 neutrons and 2 protons (and has a +2 charge)
• ~~when alpha is emitted~~ It has a high ionising power but low penetration ability
• When alpha is emitted the nucleus ~~~~ loses ~~~~ a atomic number of 2 and a mass number of 4

Gamma (γ)

• When Gamma is emitted, nucleus loses energy so electrons change their electronic configuration
• Gamma radition doesnt have any charge nor mass as it is a wave.
• It has a low ionising power, but a high penetration ability (only being stopped by thick lead walls)

(Total for Question 6 = 12 marks)

TOTAL FOR PAPER = 60 MARKS

ResultsPlus
Examiner Comments

Alpha radiation is accurately described in terms of what an alpha particle is. It goes on to describe the effect on the nucleus when an alpha particle is emitted. Gamma radiation is also described as a wave with no mass or charge. It also mentions that the nucleus loses energy. The response fully addresses the question and the examiner had no hesitation in placing it at Level 3 for 6 marks.

Alpha radiation is a type of radioactive decay within the ~~nucleus of an unstable atom~~ unstable nucleus of an atom. The radiation consists of the atom's nucleus emitting a Helium nucleus, which subtracts the atom's mass number by 4 and its atomic number by 2: ~~?~~ $^{35}_{17}C \longrightarrow {}^{31}_{15}C + {}^{4}_{2}He$

This radiation has the shortest wavelength of a maximum of 5cm, it is the least penetrating type of radiation as it can be reflected by a sheet of paper. However, it is the most ionising, meaning that it can easily knock electrons off shells and create ions during radioactive decay.

In contrast, gamma radiation does not consist of any particles as it is an electromagnetic wave. This radiation has no effect on the mass of the nucleus of an atom. Gamma radiation has a longer wavelength than alpha radiation, but Gamma is the most penetrating, as it's waves can easily pass through a human body and other objects besides a thick layer of lead. Additionally, it is the least ionising, as no particles are involved so no electrons are knocked off of shells to form ions.

ResultsPlus
Examiner Comments

Here alpha particles are accurately described as helium nuclei and the effect on the nucleus is to decrease the mass number by 4 and the atomic number by 2. Gamma radiation is correctly described as an electromagnetic wave and when emitted, the mass of the nucleus does not change. Once again, this is a clear comparison between the two types of radiation and is a Level 3 answer that scored 6 marks.

A Level 2 answer would typically compare the two types of radiation in terms of their nature but not describe the effect on the nucleus when emitted.

Alpha is ~~it~~ a helium nucleus and has 2 protons and nuetrons with the equation $^{4}_{2}He$. It is highly ionising but has low pentration ability. ~~alpha~~ alpha is normally stopped by paper, between 6-8cm. Has a mass of 4 and a charge of 2. Gamma is a electromagnetic (small waves) wave with high wave energy but a low frequency. ~~It~~ can be stopped by lead with a distance over 200m. It has low ionising ability but is highly penetrating, gamma is dangerous if not protected it can cause cancer. It has no charge or mass.

ResultsPlus
Examiner Comments

The structure of an alpha particle is accurately described but there is no description of the effect on the nucleus when emitted. Similarly, the nature of gamma radiation is correctly described as an electromagnetic wave, even though it is not correct to say that it has a low frequency. It is also correctly described as having no charge or mass, but there is no mention of the effect on the nucleus. In summary this response is a limited comparison of the two types of radiation with some inaccuracy and is a Level 2 answer. It scored 4 marks.

Many candidates included comparison of the ionisation and/or penetrating properties of the radiation. Whilst these were not descriptions of the radiation (but rather the effects of the radiation on matter), such information could be credited as contributing to an otherwise incomplete response but placing it at the lower end of the appropriate level.

*(c) Radioactive decay can produce gamma radiation and alpha radiation.

Compare the processes of gamma decay and alpha decay.

Your answer should include

- a description of both gamma radiation and alpha radiation
- the effect of each type of decay on the original nucleus.

(6)

Alpha ~~radiation~~ decay happens to larger nucleus because it emitts a helium nucleus (2 protons and 2 neutrons). Alpha radiation has a higher ionising power than gamma radiation but alpha has a really low penetrating power (only through a few cm of air or through paper). Gamma decay causes the nucleus to emitt a gamma particle which has a higher penetrating power than alpha - stopped by a few mm of lead or concrete.

Gamma radiation is much more dangerous than alpha radiation and its used to sterilise medical treament instruments. If a person is exposed to lots of gamma radiation, it could cause them harm. Alpha radiation is similar to the lower half of the EM spectrum like maybe radio waves or microwaves. Radiowaves are used in Wifi, phones and television.

ResultsPlus
Examiner Comments

An alpha particle is correctly described; both as a helium nucleus and consisting of 2 protons and 2 neutrons. Although it says that the nucleus emits an alpha particle, it does not mention the effect on the nucleus, for example a change in mass or atomic number. There is no description of gamma radiation either in terms of what it is nor its effect on the nucleus but there is a comparison of the two types of radiation in terms of their ionisation and penetrating effects. This comparison partially compensates for the lack of description of the effects on the nucleus and allows the examiner to place this at the lower end of Level 2 for 3 marks.

Paper Summary

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

- Make sure that they have a sound knowledge of the fundamental ideas in all the topics.
- Get used to the idea of applying their knowledge to new situations by attempting questions in support materials or previous examination papers.
- When describing a practical procedure, make sure they are clear how the equipment is used and how the measurements will be taken.
- Where a question involves a calculation, make sure they understand the physics of the situation before recalling or selecting an equation to use in the calculation.
- Make sure that they recognise SI prefixes such as n and k and M and how to handle these in calculations.
- Use the marks at the side of a question as a guide to the form and content of their answer.

Grade boundaries

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