

Examiners' Report

June 2023

GCSE Physics 1PH0 1H

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June 2023

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Introduction

This was the second examination of paper 1, at Higher Level, for this specification in a summer series since summer 2019.

Questions were set to test candidates' knowledge, application and understanding from these topics in the 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. The inclusion of questions designed at targeting candidates' knowledge and understanding of practical work continued. This included assessing their fundamental knowledge of practicals specified in the specification, together with further application.

One of the six-mark questions tested knowledge and understanding of the principle of a controlled nuclear chain reaction in a nuclear reactor.

The other six-mark question was based on a core practical about the relationship between force, mass and acceleration.

Candidates coped well with most questions and did particularly well in the questions asking for calculations using equations. Students' knowledge of practical work shows improvement on last year. This was shown particularly in Q2(b)(ii) and Q9(c).

Successful candidates:

- were well-acquainted with the content of the specification
- had been engaged with practical work at some stage during their course
- were competent in quantitative work, especially in using equations
- were willing to apply physics principles to the novel situations presented to them
- 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 conceptual knowledge of the topics in this paper
- had gaps in their procedural knowledge, relating to their practical work
- misread and/or misunderstood the symbols used in equations
- failed to set out calculations in a logical way that could be easily followed
- did not focus sufficiently on what the question was asking
- found difficulty in applying their knowledge to new situations

Question 1 (a)

This was a calculation involving the wave equation, $v = f \times \lambda$, given in the question. The wavelength had to be converted from mm to m and the equation had to be rearranged.

The vast majority of candidates scored at least 1 of the 2 marks with the most common error involving the unit conversion.

1 Figure 1 shows a bat and its prey.



Figure 1

The bat emits a high frequency sound pulse to locate its prey.

The speed of sound in air is 330 m/s.

(a) The wavelength of the sound is 11 mm.

$$11 \div 1000 = 0.011$$

Calculate the frequency of the sound.

(2)

Use the equation

$$v = f \times \lambda$$

$$f = v / \lambda$$

$$v = f \times \lambda$$

$$f = 330 / 0.011 = 30000$$

frequency = 30000 Hz



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Examiner Comments

The working is clear, showing the unit conversion, rearrangement and correct final answer.

2 marks.

Question 1 (b)

A more complex calculation, involving the idea of echolocation and a unit conversion in the time taken.

Most candidates were able to score at least 2 of the 4 marks available. The most common errors were in unit conversion and not dividing the overall distance or time by two.

(b) The pulse returns to the bat after a time of 18 ms.

Calculate the distance from the bat to its prey.

(4)

$$s = \frac{d}{t}$$
$$\frac{330 \times 18}{2} = 2970$$

distance = $\frac{2970}{5940}$ m



ResultsPlus
Examiner Comments

This response has an error in the unit conversion but is otherwise correct.

3 marks.

(b) The pulse returns to the bat after a time of 18 ms.

Calculate the distance from the bat to its prey.

$$18 \text{ ms} = 0.018 \text{ sec} = \text{time}, \div 2 = \frac{9}{1000}, (0.009) \quad (4)$$

$$\text{Speed} = 330$$

$$d = 330 \times \frac{9}{1000} = 2.97$$

$$\text{distance} = 2.97 \text{ m}$$



ResultsPlus
Examiner Comments

This response has the correct answer and scores all 4 marks.

Question 2 (b)(i)

A practical based question in which candidates had to describe how to investigate the relationship between the speed of a falling stack of cupcake cases and the number of cases in the stack.

The description had to include the measurement of distance and time and the calculation of speed for several stacks with different numbers of cases.

This was well answered with the vast majority of candidates scoring at least 1 of the 4 marks available and most of those scoring 3 or 4 marks.

(i) The student also has a stop clock and a metre rule.

Describe an investigation to show how the speed of the falling stack of cupcake cases depends on the number of cupcake cases in the stack.

(4)

They could place the ~~an~~ amount of ~~cupcake~~ cupcake into a stack and place it alongside a metre rule and ~~the~~ note down the initial reading of distance. They could then drop the stack of cupcake and ~~use~~ use the stop clock to time how long it takes for the stack to fall. Then using the equation $\text{speed} = \frac{\text{distance}}{\text{time}}$ they could find the speed. They could then increase the number of cupcake into the stack and repeat.



ResultsPlus
Examiner Comments

This response describes the measurement of distance and time and the calculation of speed and, at the very end, they say increase the number of cases in the stack and repeat.

4 marks.

Question 2 (b)(ii)

A straightforward calculation of weight, given the mass and the equation. Most candidates did this correctly.

Question 2 (b)(iii)

Candidates had to draw an arrow on a diagram to show the force due to air resistance on a falling cupcake case.

Almost all candidates were able to do this.

Question 2 (b)(iv)

Here, candidates had to understand that an object falling at constant velocity has zero acceleration.

Most, but by no means all, answered this correctly.

Question 3 (a)(i)

A straightforward gravitational potential energy calculation, involving a rearrangement.

As expected, most candidates scored all 3 marks.

3 (a) Figure 5 shows a football kicked against a wall.

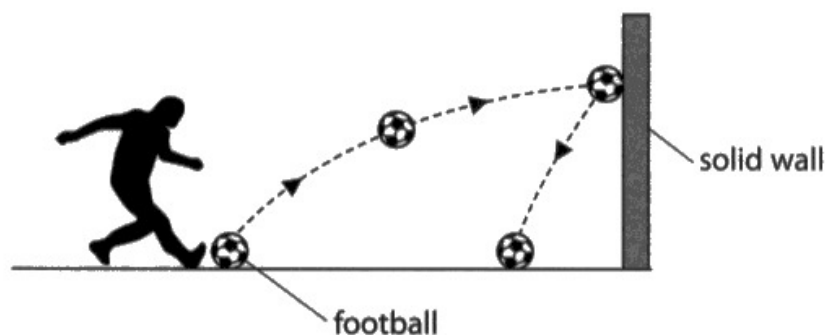


Figure 5

The football has a mass of 0.42 kg.

- (i) The football gains 11 J of gravitational potential energy as it moves from the ground to the wall.

Calculate the height at which the ball hits the wall.

(3)

Gravitational field strength = 10 N/kg

Use the equation

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

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

$$\frac{11}{0.42 \times 10} = 2.619047$$

height = 2.62 m



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Examiner Comments

All steps in the working are clearly shown here, resulting in all 3 marks.

Question 3 (a)(ii)

A straightforward kinetic energy calculation.

As expected, most candidates scored all 2 marks.

- (ii) Calculate the kinetic energy of the football when it is moving at a velocity of 12 m/s.

(2)

Use the equation

$$KE = \frac{1}{2} \times m \times v^2$$

$$KE = \frac{1}{2} \times 0.42 \times 12^2$$

$$KE = 30.24 \text{ J}$$

kinetic energy = 30.24 J



ResultsPlus
Examiner Comments

Working clearly shown, resulting in both marks.

Question 3 (a)(iii)

Examiners were looking for a description involving kinetic energy (before the collision) and a range of possibilities for the energy after the collision.

Most candidates were able to score at least 1 of the 2 marks available.

(iii) Describe the energy transfers that happen when the ball hits the wall.

(2)

Energy is transferred mechanically from
the kinetic energy store of the ball to
the thermal energy store of the wall.



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Examiner Comments

This was a perfectly acceptable description for 2 marks.

Question 3 (b)

This proved to be a more challenging question than expected. Candidates had to first realise that the acceleration was 10 m/s^2 (acceleration due to gravity) then select an appropriate equation to use.

The majority of candidates did not score here with about half of those who did score going on to score both marks.

(b) A stone is held at rest above the ground.

The stone is released and falls until its velocity is 17 m/s.

Calculate the distance the stone has fallen when its velocity has reached 17 m/s.

(2)

$$\begin{aligned} v &= x/t \\ a &= 10 \text{ m/s}^2 \\ v^2 - u^2 &= 2ax \\ x &= \frac{v^2 - u^2}{2a} \\ &= \frac{17^2 - 0^2}{2 \times 10} \end{aligned} \quad \left. \begin{array}{l} \\ \\ \\ \end{array} \right\} \begin{aligned} &= \frac{17^2}{20} \\ &= 14.45 \text{ m} \\ &= 14 \text{ m} \end{aligned}$$

distance = 14 m



ResultsPlus
Examiner Comments

After (correctly) deciding not to use $v = x/t$, this candidate went on to select the correct equation and the correct acceleration and arrive at the correct answer.

2 marks.

Question 4 (a)(i-ii)

This was an introduction to a question on red shift. Candidates had to calculate the velocity of a moving object, given the equation.

The difficulty here was in selecting the correct data from the information at the start of the question. Most were able to do this successfully.

- 4 (a) Figure 6 shows two objects, **E** and **D**.

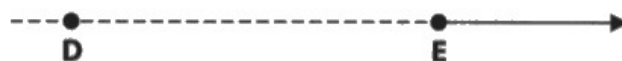


Figure 6

E emits a sound.

D detects the sound.

E is moving in the direction shown by the arrow, but **D** is not moving.

E emits a sound of wavelength 1.86 m.

D measures the wavelength of this sound as 1.98 m.

- (i) Calculate the difference between the wavelength that **E** emits and the wavelength that **D** detects.

(1)

$$1.98 - 1.86 \\ = 0.12 \text{ m}$$

difference in wavelength = m

- (ii) The velocity of sound is 330 m/s.

Calculate the velocity of **E**.

(2)

Use the equation

$$\text{velocity of E} = \frac{\text{velocity of sound} \times \text{difference in wavelength}}{\text{wavelength E emits}}$$

$$\text{Velocity of E} = \frac{330 \times 0.12}{1.86}$$

$$E = 21.3$$

velocity of **E** = 21.3 m/s



ResultsPlus
Examiner Comments

Clear working shown at each step.

3 marks.

Question 4 (b)

In this question about evidence for the expansion of the Universe, candidates had to say that the detected wavelength was increasing then go on to say that this showed the galaxies were moving away (from Earth).

Most scored at least 1 mark with about half going on to score both marks.

- (b) The wavelength of light emitted from distant galaxies is different when the light is detected on Earth.

Explain how this difference in wavelength shows that the Universe is expanding.

Because the red-shift detected from distant galaxies shows that the wave length is increasing, meaning that they are moving further away from us. ⁽²⁾



ResultsPlus
Examiner Comments

A clear, succinct response.

2 marks.

Question 4 (c)

Here, candidates had to know that the 'M' in 'CMB' meant 'microwave' then select the appropriate value from the table.

Just over half the candidates were able to do this.

Question 4 (d)(i-ii)

The explanation asked for here had to link what causes a nebula to collapse with the increase in temperature, the start of nuclear fusion and the resulting equilibrium in a main sequence star.

There was an almost even spread of marks here in all marks between 0 and 4.

(d) During the evolution of a star, the nebula collapses and becomes a main sequence star.

(i) State what causes the nebula to collapse.

(1)

inwards force of gravitational pull

(ii) Explain why the nebula stops collapsing as it becomes a main sequence star.

(3)

The inwards force of gravity causes the nebula to become extremely hot and dense. When temperatures and pressure are high enough, this will allow nuclear fusion of hydrogen atoms to occur. Eventually, the outwards force of the energy emitted becomes balanced with the inwards gravitational pull, so the star enters a stable phase where it is called a main sequence star.



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Examiner Comments

This response is sufficient for all 4 marks.

Question 5 (b)

Most candidates could identify the maximum velocity of the lift and read the correct value from the graph.

Question 5 (c)

Candidates had to use the graph to determine the acceleration of the lift. They could do this either by finding the gradient of the graph or using the equation for acceleration using suitable data points from the graph.

Most were able to score all 3 marks.

- (c) Use the graph in Figure 8 to determine the acceleration of the lift during the first 1.4 s.

$$\begin{aligned} \text{acceleration} &= \frac{4 - 0}{1.4} & (3) \\ &= \frac{4}{1.4} = \frac{20}{7} = 2.857142 \end{aligned}$$

acceleration = 2.86 m/s²



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Examiner Comments

Here the gradient of the graph was successfully calculated.

3 marks.

(c) Use the graph in Figure 8 to determine the acceleration of the lift during the first 1.4s.

(3)

$$a = \frac{(v-u)}{t}$$

$$a = \frac{(4-0)}{1.4}$$

$$a = 2.857142$$

$$a = 2.9$$

$$\text{acceleration} = \dots\dots\dots 2.9 \dots\dots\dots \text{m/s}^2$$

$$a = ? \quad v = 0$$

$$v = 4 \quad t = 1.4$$



ResultsPlus
Examiner Comments

Here the equation for acceleration was used with suitable data points from the graph.

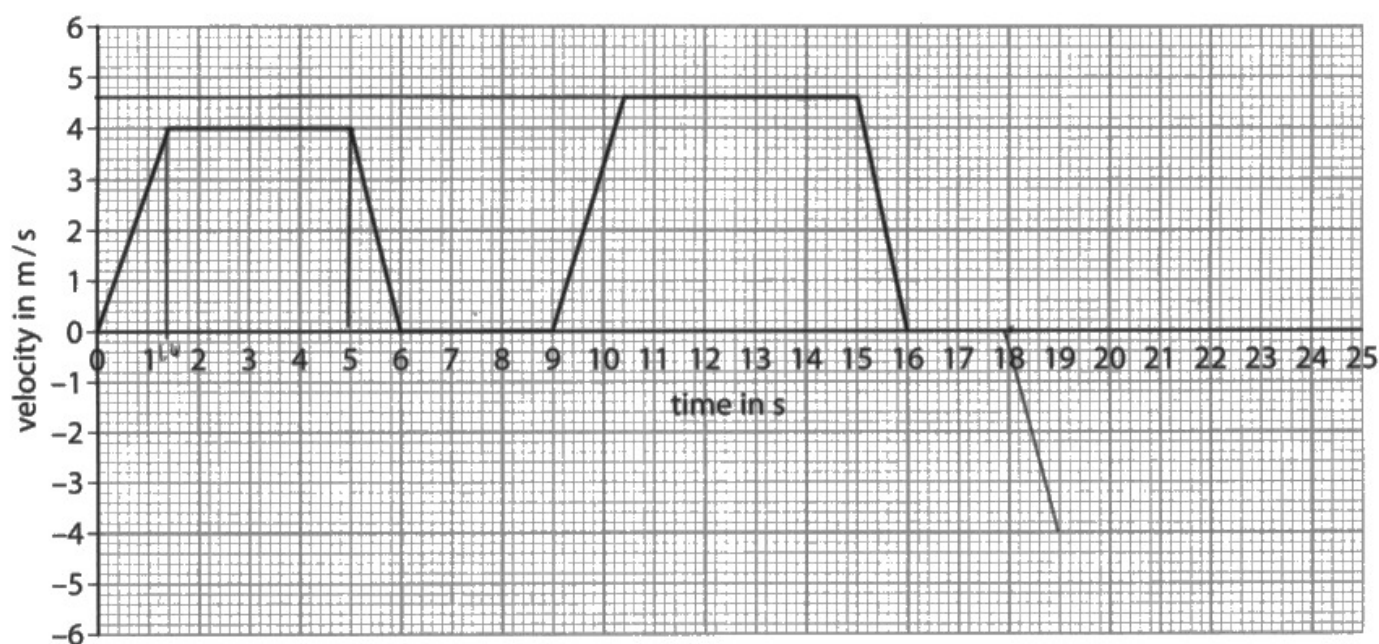
Question 5 (d)

This was a more challenging question in which candidates were asked to determine a distance from a velocity/time graph.

This meant calculating the area under the graph which some did using the area of a trapezium others by calculating the areas of the two triangles and the rectangle and adding them together.

There was a range of scores for this question.

5 Figure 8 is a velocity/time graph for a lift moving upwards in a tall building.



(d) Use the graph in Figure 8 to determine the distance that the lift travelled during the first 6.0 s.

(3)

$$\frac{1.4 \times 4}{2} = 2.8$$

$$\frac{1 \times 4}{2} = 2$$

$$2 + 2.8 + 14.4 = 19.2$$

$$3.6 \times 4 = 14.4$$

distance = 19.2 m



Here the candidate calculated the areas of the two triangles and the rectangle and added them together.

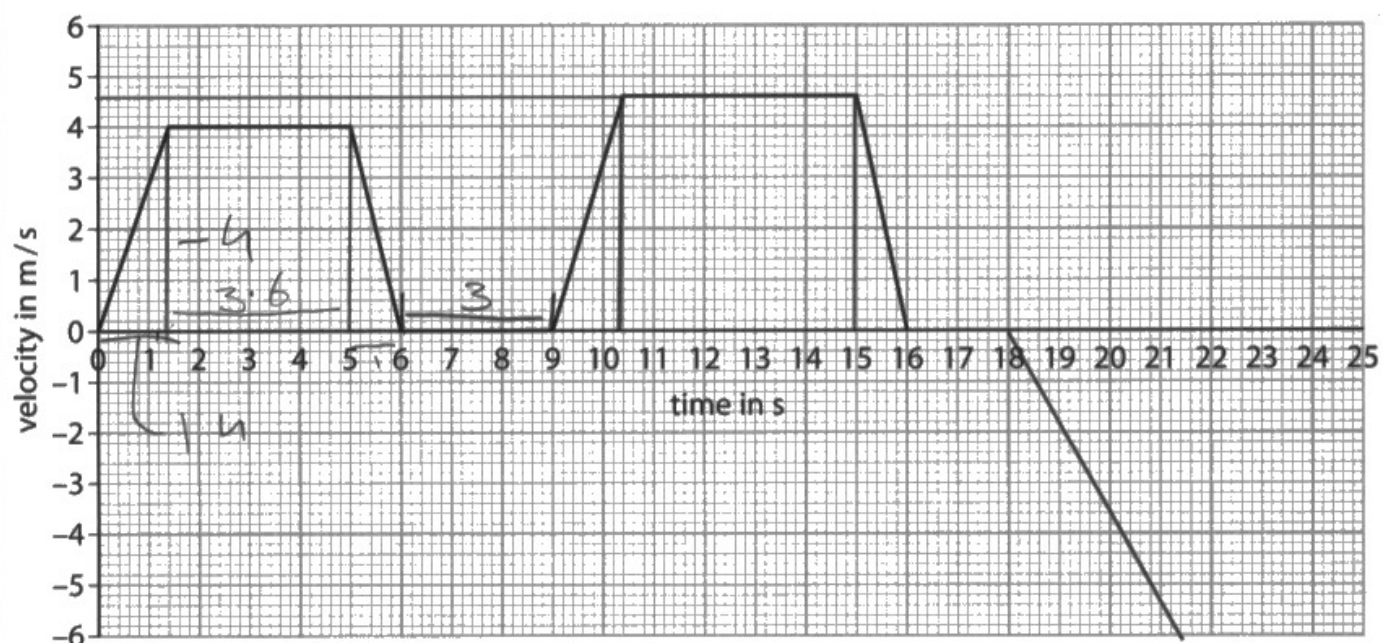
3 marks.

Question 5 (e)

Candidates had to draw a line on the graph to show the lift moving downwards after 18s.

Most were able to do this successfully.

5 Figure 8 is a velocity/time graph for a lift moving upwards in a tall building.



(e) At 18s, the lift starts to move downwards.

Sketch a line on the graph in Figure 8 to show the lift moving downwards after 18s.



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Examiner Comments

The length of the line was not important. It had to start at 18s, be below the time axis and show time going forwards.

Question 6 (a)(i)

A question based on analysis of typical results in a practical, this was a two stage calculation.

Candidates had to calculate a reaction time as a percentage of a time of travel for a sound wave, having first calculated the time of travel.

A very pleasing number of candidates were able to score all 3 marks here.

- 6 (a) Figure 9 shows two technicians, L and M, measuring the speed of sound in air.



Figure 9

L fires a starting pistol.

M starts a stopwatch when first seeing the smoke from the starting pistol.

M stops the stopwatch when hearing the bang made by the starting pistol.

The distance between L and M is 120 m.

M's reaction time is 0.23 s.

The speed of sound in air is 330 m/s.

- (i) Calculate M's reaction time as a percentage of the time sound takes to travel from L to M.

$$\begin{aligned}
 \text{speed} &= \frac{\text{distance}}{\text{time}} & \text{reaction time} &= 0.23\text{ s} \quad (3) \\
 330\text{ m/s} &= \frac{120}{t} & &= \frac{0.23\text{ s}}{0.36\text{ s}} \times 100 \\
 t &= \frac{120\text{ m}}{330\text{ m/s}} & &= 63.8\% \\
 t &= 0.36\text{ s} & &
 \end{aligned}$$

..... 63.8 %



Time of travel clearly calculated on the left hand side of the page and the correct percentage calculated on the right hand side of the page.

3 marks.

Question 6 (b)

This question was about how sound waves and light waves are refracted at an air water boundary. It proved to be very challenging for many candidates. Those who did score, however, usually went on to score all 3 marks.

- (b) Figure 10 shows the difference in refraction of sound waves and light waves when these waves travel from air into water.

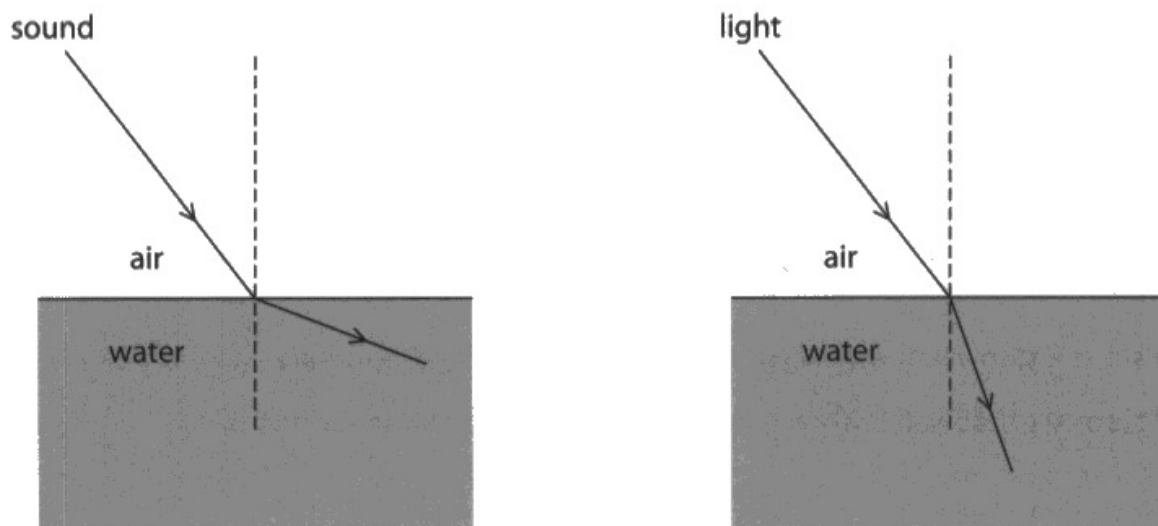


Figure 10

Explain why the refraction of the sound wave is different from the refraction of the light wave in Figure 10.

(3)

Because sound travels faster in denser mediums as there are more vibrations whereas light does not. And water is more dense than air so the sound wave will speed up causing it to bend away from the normal and the light wave will slow down causing it to bend towards the normal.



This candidate knew that light waves slowed down when entering water and this caused a change in direction towards the normal. The change in direction for sound waves was away from the normal meaning sound speeded up when entering water.

3 marks

Question 6 (c)

Most candidates were able to score at least 3 of the four marks available for giving examples of electromagnetic waves transferring energy.

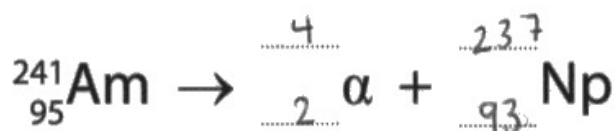
Question 7 (a)(iii)

This item was about balancing nuclear equations.

Most candidates were able to score at least 1 mark with many going on to score all 3.

(iii) Complete the equation in Figure 12 for americium-241 decaying into neptunium (Np).

(3)



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Examiner Comments

Candidates were required to recall the relevant numbers for the alpha particle then work out the numbers for the neptunium nucleus, which this response does perfectly.

3 marks

Question 7 (b)

Candidates were required to use the concept of half-life and the data supplied to calculate the co-ordinates for the next three points on a decay curve and plot them on the grid supplied.

A pleasing number were able to score at least 1 mark with many going on to score all three.

(b) The activity of a radioactive source is measured as 128 Bq.

This is shown as a point on the graph in Figure 13.

(3)

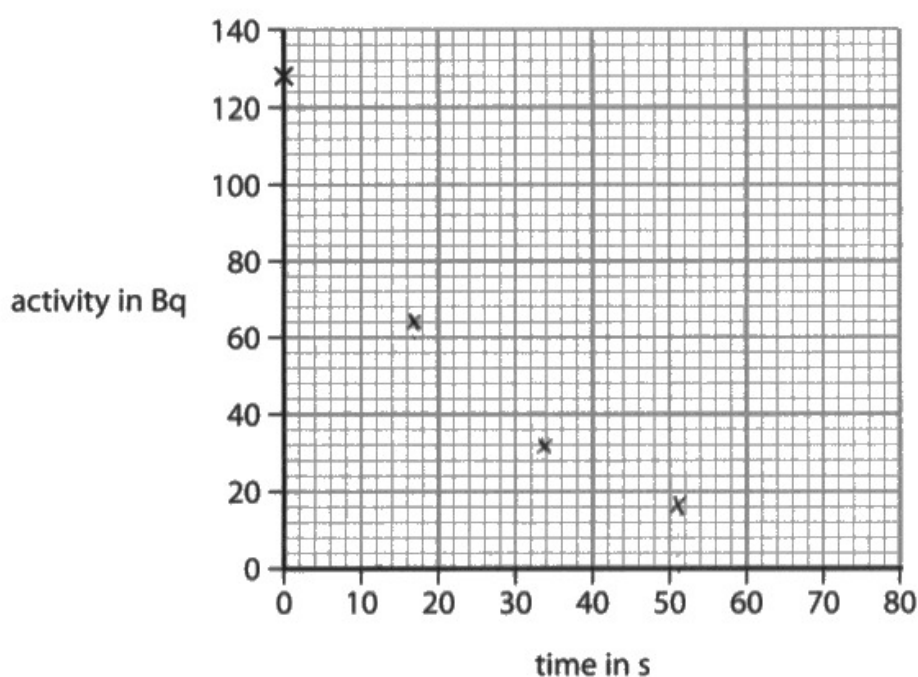


Figure 13

The half-life of this radioactive source is 17 s.

Use this information to plot three more points on the graph grid in Figure 13 to show how the activity of the source changes with time.



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Examiner Comments

Three, accurately plotted correct points on what is an unusual scale.

3 marks.

Question 7 (c)

See below.

There was an even spread of marks between 0, 1 and 2 for this description of positron emission.

(c) Describe what happens in the nucleus of an atom when a positron is emitted.

(2)

Proton converts into a neutron +
positron

- neutron stays in nuclei, positron
emitted

(Total for Question 7 = 10 marks)



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Examiner Comments

An accurate description of what happens in the nucleus of an atom when a positron is emitted.

2 marks.

Question 8 (a)(ii)

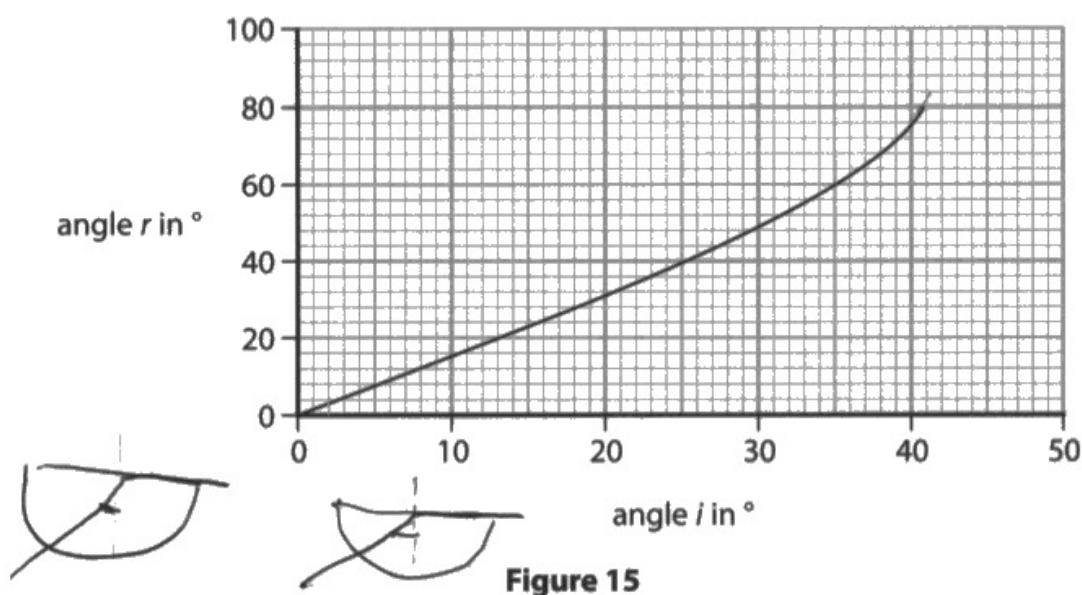
A challenging question.

Candidates needed to understand what critical angle was and then describe how it could be determined from the graph.

Only a few candidates scored all 3 marks.

(ii) The student repeats the procedure for different values of angle i .

Figure 15 is a graph of the student's results.



Describe how the student should use the graph in Figure 15 to determine the critical angle for glass.

(3)

The students would need to extrapolate the graph until angle r is 90° . Then they would need to use that to find the corresponding angle i . The angle i where angle r is 90° is the critical angle.



This candidate clearly understands what critical angle is, how the curve should be extrapolated and how the critical angle can be determined from it.

3 marks.

Question 8 (b)(i)

Q8(b)(i) was an introduction to the more demanding Q8(b)(ii).

Full marks (2) could be achieved here by simply stating that **P** was a better absorber (of radiation) than **Q**.

Question 8 (b)(ii)

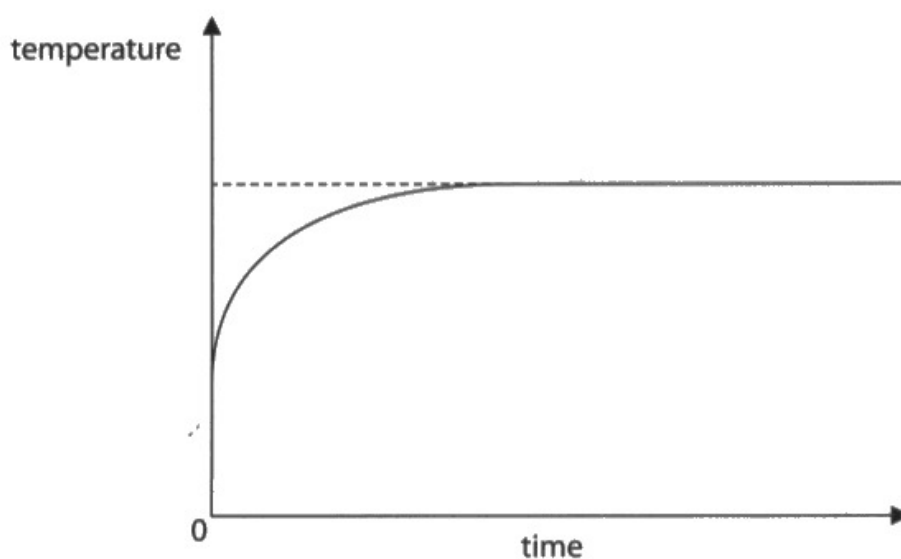
A difficult concept to get completely correct.

Candidates needed to explain that **P** was emitting radiation as well as absorbing it. When it was at a constant temperature, the **rate** of emission was equal to the **rate** of absorption.

It produced the expected spread of marks between 0 and 4.

(ii) The heater remains switched on.

Figure 17 shows how the temperature of sphere **P** changes with time.



Explain why the temperature of **P** reaches a constant value, even though the heater remains switched on.

(4)

The sphere has reached equilibrium.
The sphere dissipates thermal energy to the surroundings at the same rate which it absorbs the thermal energy. To increase the value, increase the heater's heat.



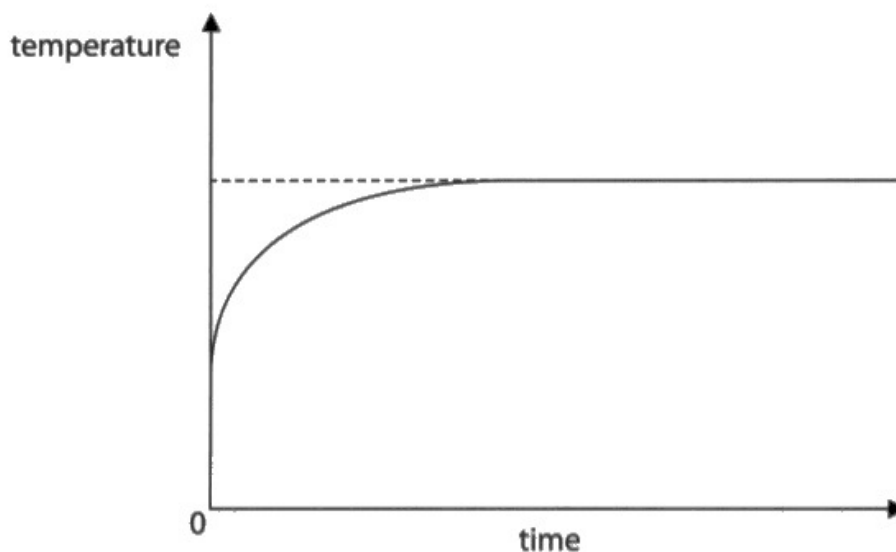
ResultsPlus
Examiner Comments

This is a succinct, accurate response with all the correct points for full marks.

4 marks.

(ii) The heater remains switched on.

Figure 17 shows how the temperature of sphere **P** changes with time.



Explain why the temperature of **P** reaches a constant value, even though the heater remains switched on.

(4)

The amount of heat being absorbed and the amount of heat being emitted are equal so the temperature is not increasing as all of the heat that is emitted is being replaced by the same amount of heat that was absorbed.



ResultsPlus
Examiner Comments

This has the emission and absorption and the idea of equilibrium at constant temperature but has not said it is the **rates** of emission and absorption that are equal.

Scores 3 of the 4 marks available.

Question 9 (a)

Q9 was about momentum and Newton's second law.

Q9(a)(i) involved candidates selecting and using the appropriate equation for momentum. The only issue here was the use of standard form with negative indices.

It was very pleasing to note that the vast majority of candidates scored all 3 marks for this calculation.

- 9 (a) An atom of mass 6.6×10^{-26} kg is moving with a velocity of 480 m/s.

Calculate the momentum of the atom.

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

(3)

$$6.6 \times 10^{-26} \times 480 = 3.168 \times 10^{-23}$$

$$\text{momentum} = 3.168 \times 10^{-23} \text{ kg m/s}$$



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Examiner Comments

Clear working and the correct answer.

3 marks.

Question 9 (b)

Q9(b) was a complex calculation involving force, rate of change of momentum and the vector nature of momentum in a collision.

(b) Figure 18 shows a ball before and after it collides with a wall.

The arrows show the direction of movement of the ball.

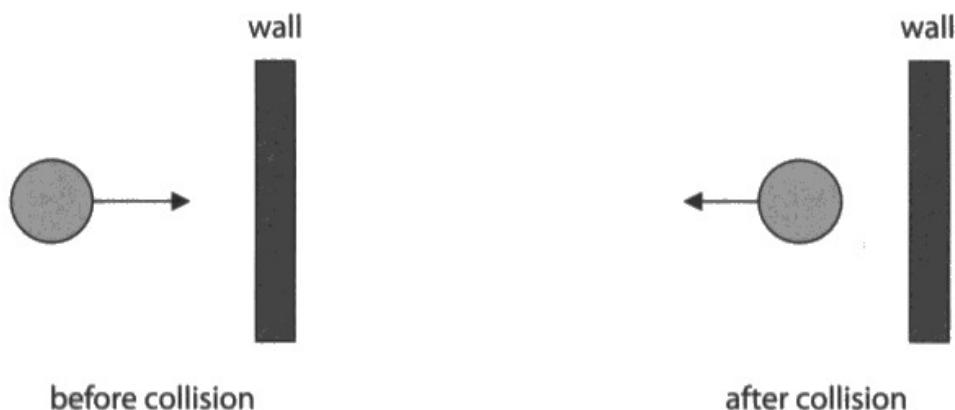


Figure 18

Before the collision, the momentum of the ball is 0.80 kg m/s .

After the collision, the momentum of the ball is 0.60 kg m/s in the opposite direction.

-0.6
 0.07 s

The ball is in contact with the wall for a time of 70 ms during the collision.

Calculate the force exerted on the ball by the wall.

(3)

Use an equation selected from the list of equations at the end of the paper.

$$\text{force} = \frac{\text{change in momentum}}{\text{time}}$$

$$f = \frac{(-0.6 - 0.8)}{0.07}$$

$$f = -20$$

$$\text{force} = \underline{-20} \text{ N}$$



This response shows the correct momentum change has been determined, substituted into the correct equation with the correct time, producing the correct answer. Full marks.

3 marks.

(b) Figure 18 shows a ball before and after it collides with a wall.

The arrows show the direction of movement of the ball.



Figure 18

Before the collision, the momentum of the ball is 0.80 kg m/s .

After the collision, the momentum of the ball is 0.60 kg m/s in the opposite direction.

The ball is in contact with the wall for a time of 70 ms during the collision.

Calculate the force exerted on the ball by the wall.

(3)

Use an equation selected from the list of equations at the end of the paper.

$$\text{MOMENT of force} = \text{force} \times \text{distance (direction)}$$

$$0.60 + 0.80 = 1.4$$

$$\frac{1.4}{70} = 0.02$$

$\frac{w}{F/D}$

force = 0.02 N



ResultsPlus
Examiner Comments

This response has everything correct except the time. The time should be 70×10^{-3} (70 ms).

2 marks.

(b) Figure 18 shows a ball before and after it collides with a wall.

The arrows show the direction of movement of the ball.

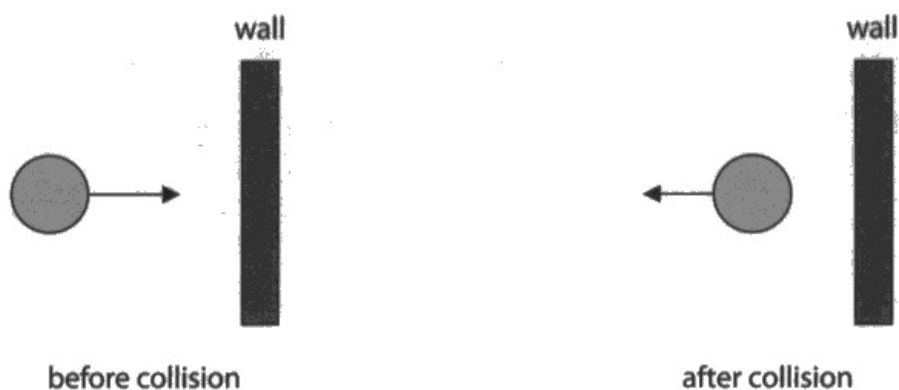


Figure 18

Before the collision, the momentum of the ball is 0.80 kg m/s .

After the collision, the momentum of the ball is 0.60 kg m/s in the opposite direction.

The ball is in contact with the wall for a time of 70 ms during the collision.

Calculate the force exerted on the ball by the wall.

0.7 s

(3)

Use an equation selected from the list of equations at the end of the paper.

Force = $\frac{\text{change in momentum}}{\text{time}}$

$$F = \frac{\Delta p}{t}$$

$$= \frac{0.80 - 0.60}{0.7} = \frac{0.2}{0.7} = 0.285714$$

ANSWER to 2 s.f.

force = 0.3 N

(rounded to 2 s.f.)



ResultsPlus
Examiner Comments

This response attempts to find the change in momentum so scores the first mark.

It does not account for the change in direction of the momentum or the fact that the time is given in ms so scores no further marks.

1 mark.

Question 9 (c)

To achieve level 1, candidates had to present at least two isolated, relevant statements.

To achieve level 2, candidates had to give details of at least **one** element of experimental procedure and one other isolated statement.

To achieve level 3, candidates had to give details of at least **two** elements of experimental procedure and one other isolated statement.

It was pleasing to note that most candidates were able to achieve at least level 2 with many going on to score full marks. Very few candidates failed to score.

*(c) Newton's second law can be stated as

$$\text{force} = \text{mass} \times \text{acceleration}$$

A student is provided with a trolley and a runway on a bench, as shown in Figure 19, and access to other equipment.

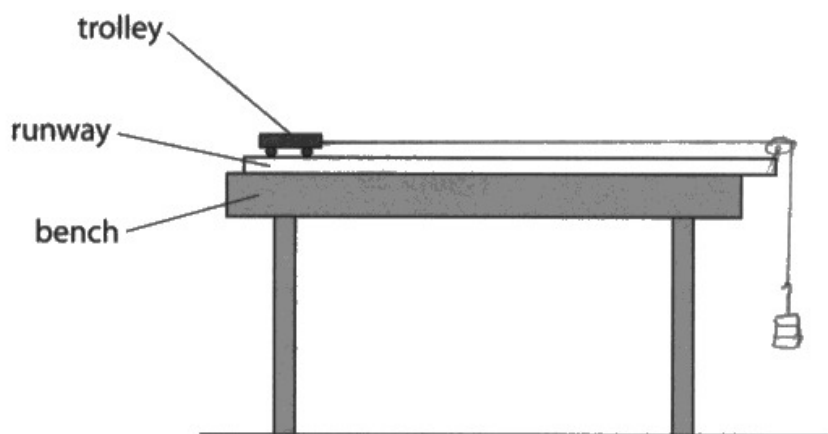


Figure 19

Describe a procedure the student could use to investigate how the acceleration of the trolley depends on the force applied to the trolley.

You may add to the diagram in Figure 19 to help your answer.

(6)

Add ~~on~~ all the weights to the car that you are going to use to ensure the mass of the system is kept constant. Remove ~~the~~ a weight and attach it to the end of a piece of string, which will pull the trolley along the bench. (The weight is the force acting on the ~~the~~ trolley). Use light gates to measure the velocity of the trolley at the start and end of the runway. Use a stopwatch to time how long it takes ~~the~~ for the car to get between each light gate. Use this to find the acceleration, which equals, ~~the~~ change in velocity $\div$ time taken. Repeat this increasing the amount of weight on the piece of string. As you increase the force, you will increase the acceleration. You may want to put the runway at a small angle to reduce the impact of friction.

(Total for Question 9 = 12 marks)



In this response, the candidate does more than enough to achieve level 3, 6 marks.

The candidate gives details of at least **three** elements of experimental procedure, the third one being better than an isolated statement.

- lines 1 to 5 describing a method to keep the mass constant
- lines 5 to 6 saying the force is provided by the weight on the string
- lines 7 to 8 saying light gates are used to measure the initial and final velocities.

Question 10 (a)(i)

For all of part (a), candidates were given information about an RTG, a power supply on a Mars rover.

Part (a)(i) was a calculation using the efficiency equation, requiring a rearrangement and using a very low efficiency.

The vast majority scored both marks for this item.

Question 10 (a)(ii)

Candidates had to suggest a property of the isotope that would make it suitable for use in the RTG.

Just over half of the candidates scored at least 1 mark for suggesting the isotope must have a long half life and slightly less than half were able to score both marks for giving a reason.

- (ii) Suggest, with a reason, **one** property the isotope must have to be suitable for use in the RTG.

(2)

~~It must be unstable so that it decays to rel~~ It must have a long half-life so it provides energy for the long term, allowing the micro rover to continue working for a long time, and does not decay too quickly.



ResultsPlus
Examiner Comments

This response suggests a long half life and carries on to say that this is so that the rover can carry on working for a long time.

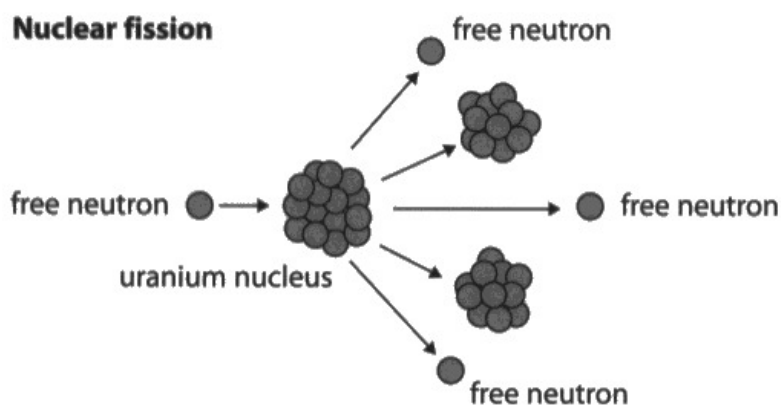
2 marks.

Question 10 (b)

The equation was given in the question in this calculation which involved a rearrangement and numbers in standard form.

Most candidates scored all 3 marks.

(b) Figure 21 shows the fission of a uranium nucleus.



(Source: adapted from © 1501926062/Shutterstock)

Figure 21

The total mass of all the particles after the reaction is less than the total mass of the particles before the reaction.

The energy released in the reaction comes from the change in mass.

This is shown in the equation

$$\text{energy released} = (\text{change in mass}) \times (\text{speed of light})^2$$

The energy released in one fission reaction = $1.49 \times 10^{-10} \text{ J}$.

The speed of light = $3.00 \times 10^8 \text{ m/s}$.

Calculate the change in mass.

(3)

$$\text{change in mass} = \frac{\text{energy released}}{(\text{speed of light})^2}$$

$$\frac{1.49 \times 10^{-10}}{(3.00 \times 10^8)^2}$$

$$1.49 \times 10^{-10} \times (3.00 \times 10^8)^2$$

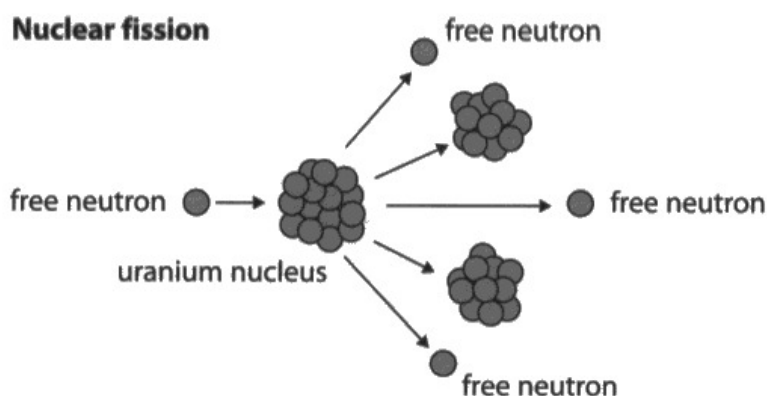
change in mass = 13410000 kg



This candidate scored 1 mark for rearranging the equation, showing that working clearly but then went on to multiply the numbers instead of dividing them.

1 mark.

(b) Figure 21 shows the fission of a uranium nucleus.



(Source: adapted from © 1501926062/Shutterstock)

Figure 21

The total mass of all the particles after the reaction is less than the total mass of the particles before the reaction.

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The energy released in one fission reaction = $1.49 \times 10^{-10} \text{ J}$.

The speed of light = $3.00 \times 10^8 \text{ m/s}$.

Calculate the change in mass.

$$\begin{aligned} \text{change in mass} &= \frac{\text{energy}}{(\text{speed of light})^2} & (3) \\ m &= \frac{1.49 \times 10^{-10}}{(3.00 \times 10^8)^2} = 1.655... \times 10^{-27} \end{aligned}$$

$$\text{change in mass} = 1.66 \times 10^{-27} \text{ kg}$$



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Clear working shown, arriving at the correct answer for full marks.

3 marks.

Question 10 (c)

A complete explanation here would include detail of how a nuclear chain reaction can release large amounts of energy and details of the roles played by control rods and moderators in controlling the rate of energy release.

To achieve level 1, candidates had to identify at least two of chain reaction, control rods, moderators.

To achieve level 2, candidates had to give detail of at least one of these and identify another.

To achieve level 3, candidates had to give detail of at least two of these and identify another.

It was pleasing to note that most candidates were able to achieve at least level two with many going on to score full marks.

*(c) The energy released in a single uranium fission is very small.

In a nuclear power station, the fission of uranium in the reactor releases large amounts of energy.

The energy released is enough to generate electricity for thousands of homes.

The demand for electricity varies.

Explain

- how large amounts of energy can be released in the reactor
- how the rate of energy release is controlled as the demand for electricity varies.

(6)

Having a lot of uranium and nuclear fission chain reactions happening can heat up water into steam but the reaction needs to be controlled. The steam will turn the turbines creating electricity in the generator, releasing a lot of energy from the reactor. The energy release is controlled by amount of uranium used and the rate of which control rods are dropped. It can also depend on the moderator to control the reaction rate. When ~~generating~~ sending electricity to homes they can change the efficiency in power lines as well in the process of meeting demands from energy dissipation.



ResultsPlus
Examiner Comments

This response identifies all three of chain reaction, control rods and moderators but does not give enough detail about any of them to achieve level two, scoring level one, 2 marks.

*(c) The energy released in a single uranium fission is very small.

In a nuclear power station, the fission of uranium in the reactor releases large amounts of energy.

The energy released is enough to generate electricity for thousands of homes.

The demand for electricity varies.

Explain

- how large amounts of energy can be released in the reactor
- how the rate of energy release is controlled as the demand for electricity varies.

Nuclear fission ^{happens} when an unstable ~~nucleus~~ ^{moderator = slow} ^{control rods = absorb neutrons} joins with a neutron to produce two daughter nuclei and more neutrons. The neutrons go on to join with more nuclei and this causes a chain reaction. ~~The energy from~~ fission releases lots of energy which ~~happens~~ is released in the reactor causing a chain reaction, and more energy to be produced. (6)

Nuclear fission is controlled using a moderator which slows down the neutrons allowing for more fission reactions. ~~and~~ ~~The~~ Control rods are also used which move up and down and absorb neutrons to allow for more or fewer neutrons to be available for fission reactions ~~What~~ and will ensure more frequent fission reactions happening.



The details of chain reactions, control rods and moderators are all sufficient for the explanation here. Any two plus a mention of the third would have been enough to achieve level three.

This scores level three, two marks.



This candidate has underlined or circled key words and phrases in the question itself. This is good practice to help structure your answer.

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 previous examination papers.
- When describing a practical procedure, draw a labelled diagram to help their answer.
- When suggesting improvements or extensions to a practical procedure, make sure they are relevant to the context of the question.
- Where a question involves a calculation, make sure they write down the equation they are using and show each step in their working.
- Make sure that they recognise SI prefixes such as m and k and n and how to handle these in calculations.

Grade boundaries

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

<https://qualifications.pearson.com/en/support/support-topics/results-certification/grade-boundaries.html>

