Pearson
Edexcel

# Examiners' Report
# June 2022

## GCSE Combined Science 1SC0 1PH

ResultsPlus

**Edexcel and BTEC Qualifications**

Edexcel and BTEC qualifications come from Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk.

Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

ResultsPlus

**Giving you insight to inform next steps**

ResultsPlus is Pearson's free online service giving instant and detailed analysis of your students' exam results.

- See students' scores for every exam question.
- Understand how your students' performance compares with class and national averages.
- Identify potential topics, skills and types of question where students may need to develop their learning further.

For more information on ResultsPlus, or to log in, visit www.edexcel.com/resultsplus. Your exams officer will be able to set up your ResultsPlus account in minutes via Edexcel Online.

**Pearson: helping people progress, everywhere**

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk.

June 2022

Publications Code 1SC0_1PH_2206_ER

## Introduction

This was the fifth year of examining this specification, being paper 3 of combined science at higher level. This examination was the first live series since 2019. Questions were set to test candidates' knowledge, application and understanding from six 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. Three questions assessed candidates' knowledge of practical procedures, namely Q1(b)(i) and Q1(b)(ii) concerning thermal insulation, Q4(b) concerning momentum conservation – this included an open response question attracting 4 marks and Q5(b) and Q5(c) about alpha particle scattering, including setting up a bench top model. The standard of answers on practical questions was variable with some candidates showing good procedural knowledge, whilst for others there was a clear lack of familiarity shown, especially with the momentum conservation investigation.

Candidates continued to do well with most calculation questions, although some didn't cope well with the units involved.

Successful candidates were:

- well-acquainted with the content of the specification
- skilled as a result of having been engaged with practical work during their course
- competent in quantitative work, especially in using equations
- well-focused in their comprehension of the question-at-hand
- willing to apply physics principles to the novel situations presented to them

Less successful candidates:

- had gaps in their conceptual knowledge of the topics of this paper
- had gaps in their procedural knowledge, relating to their practical work
- misread and / or misunderstood the symbols used in equations
- did not focus sufficiently on what the question was asking
- found difficulty in applying their knowledge to new situations

This report will provide exemplification of candidates' work, together with tips and/or comments, for a selection of questions. The exemplification will come from responses which highlight successes and pitfalls, with the aim of aiding future teaching of these topics.

## Question 1 (b)(i)

(b) A student uses the apparatus in Figure 1 to find out which of two materials, sand or sawdust, is the better insulator.

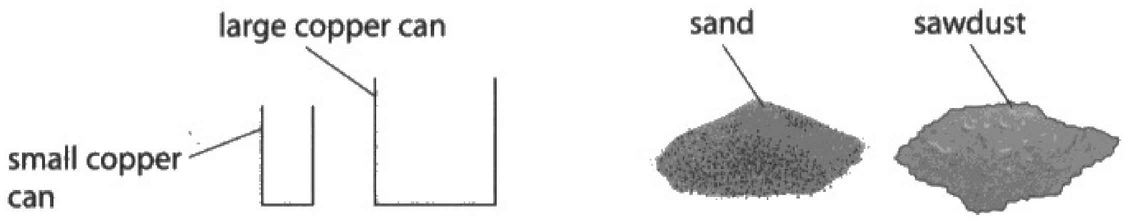
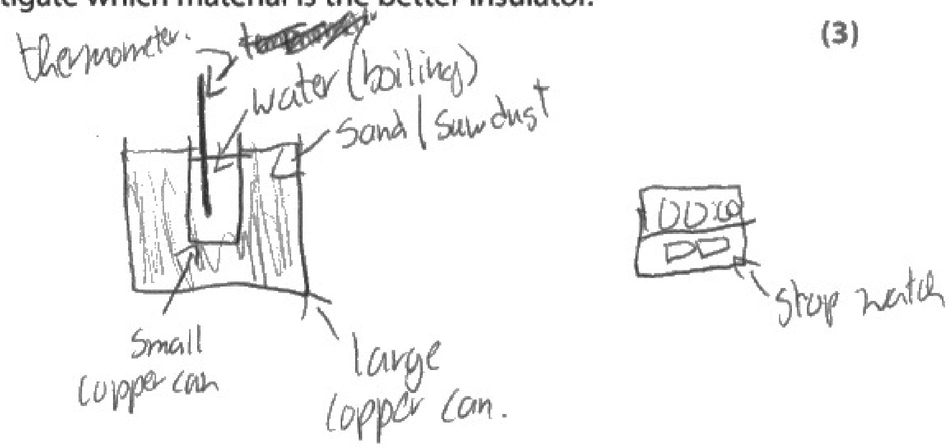



**Figure 1**

The student also has a kettle to boil water, a thermometer and a stop clock.

(i) Draw a labelled diagram to show how the student should set up the equipment to investigate which material is the better insulator.

**(3)**




b) ii) - the tempreture around the room
- the volume of boiling water
- the volume of sand or sawdust.

ResultsPlus
Examiner Comments

The use of the thermometer in water (alone) was a key differentiating feature in performance. This candidate has that, as well as the expected surround of insulator.

**ResultsPlus**
**Examiner Tip**

Candidates need to think 'What am I measuring?' and 'to what purpose?'. That ought to prevent them putting the thermometer in the sand or sawdust.

(b) A student uses the apparatus in Figure 1 to find out which of two materials, sand or sawdust, is the better insulator.

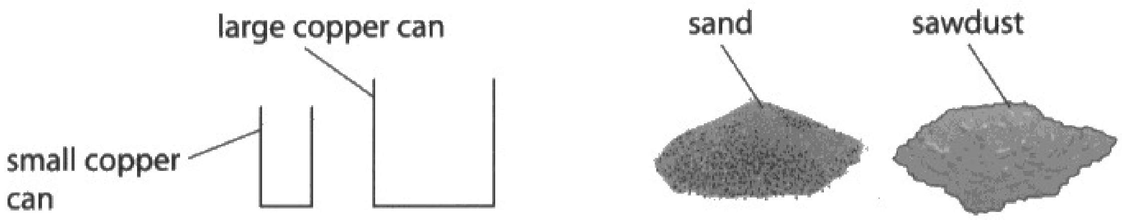
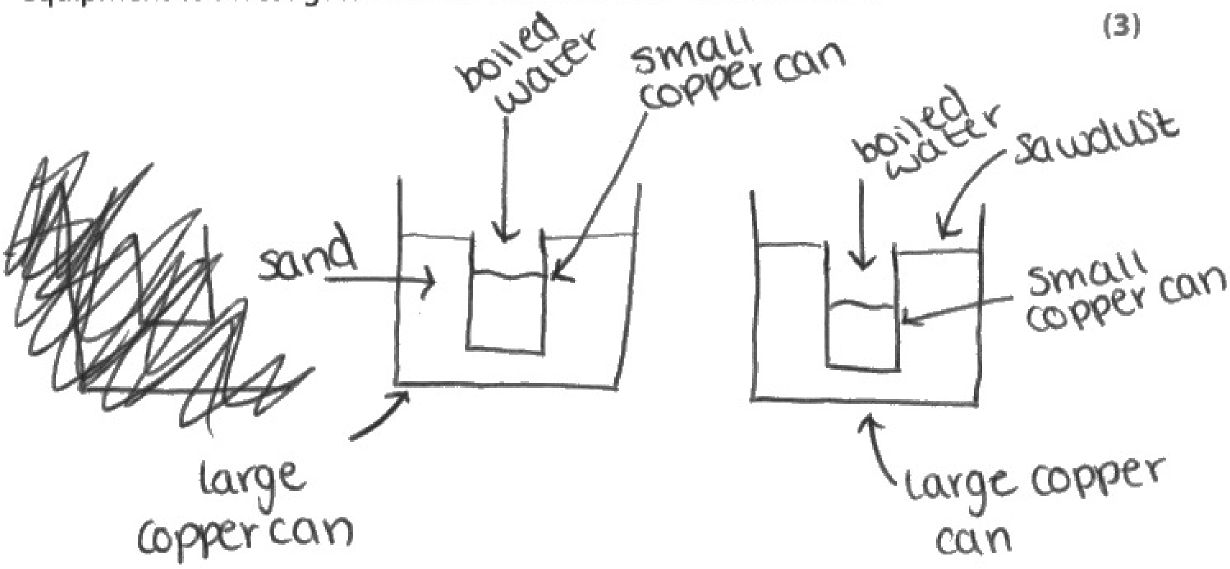



**Figure 1**

The student also has a kettle to boil water, a thermometer and a stop clock.

(i) Draw a labelled diagram to show how the student should set up the equipment to investigate which material is the better insulator.

**(3)**




**ResultsPlus**
**Examiner Comments**

This candidate produces an exemplary drawing in terms of clarity. Unfortunately they forgot to include the thermometer, without which the test wouldn't yield any conclusion. Therefore, they miss out on mark point 2 of the mark scheme.

## Question 1 (b)(ii)

(ii) Give **three** factors that the student must control in this investigation.

**(3)**

1 The temperature the kettle heats the water to.

2 The amount of sand/sawdust used.

3 The amount of water in the can.

ResultsPlus

Examiner Comments

Many candidates fail to appreciate the idea of control variables. So they would say 'temperature' or 'time' which are not controlled to make this a fair test. **Starting** temperature (temperature of water from the kettle) and time **interval**, over which the two tests are made are key control variables.

Notice that the candidate uses the word 'amount' for insulator and water. In this series this was allowed. That's why this candidate has scored full marks on this question. Candidates should not presume this for the future. It is scientific to specify 'thickness of insulator' and 'mass of water' and that is what should be done.

## Question 1 (c)

(c) Expanded polystyrene, used to insulate buildings, has different densities.

Figure 2 shows how the thermal conductivity of expanded polystyrene changes with the density of expanded polystyrene.

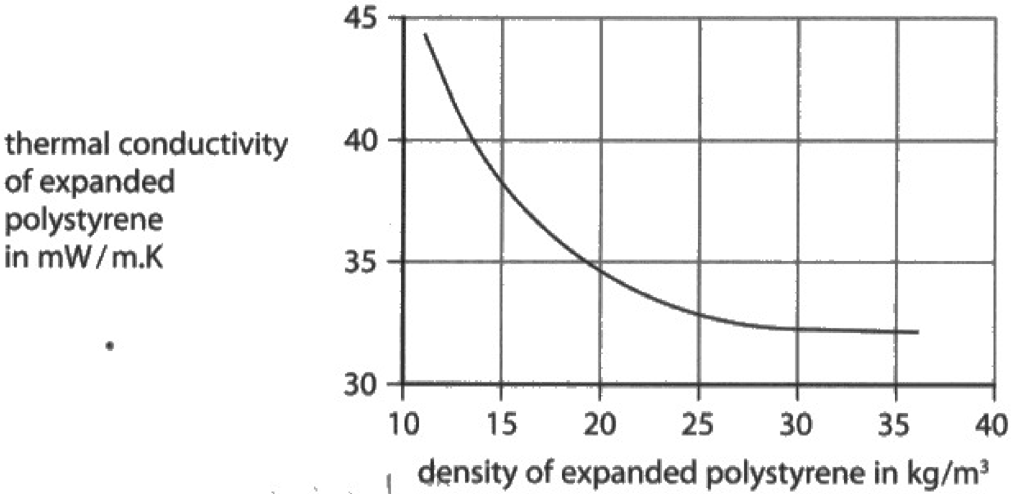



**Figure 2**

Using the graph in Figure 2, describe how the thermal conductivity of expanded polystyrene changes with the density of expanded polystyrene.

**(2)**

- Non linear slope
- ~~[illegible]~~ Decreasing thermal conductivity.
- As the density of expanded polystyrene increases the thermal conductivity decreases

**(Total for Question 1 = 9 marks)**

ResultsPlus
Examiner Comments

This is, by now, a standard graph interpretation question – 1st mark trend, 2nd non-linear idea.

This candidate has both of these responses.

A lot of candidates quoted read off data from the graph, which was not credited.

(c) Expanded polystyrene, used to insulate buildings, has different densities.

Figure 2 shows how the thermal conductivity of expanded polystyrene changes with the density of expanded polystyrene.

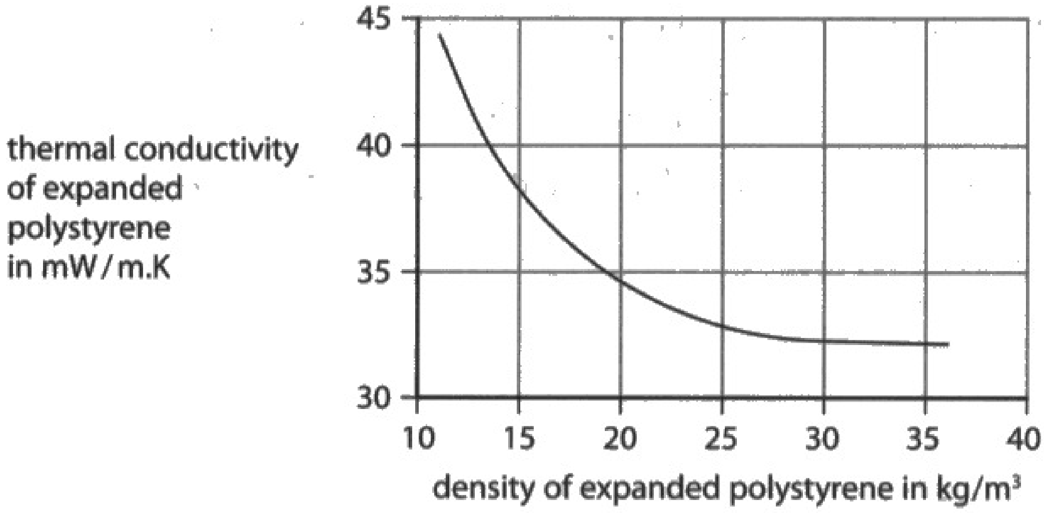



**Figure 2**

Using the graph in Figure 2, describe how the thermal conductivity of expanded polystyrene changes with the density of expanded polystyrene.

**(2)**

As the density of the expanded polystrene increases, the thermal conductivity is reduced. This is shown as at 10kg/m³ of polystrene the thermal conductivity is around 45mW/m.K, while at 35 kg/m³ it is at around 32.5mW/m.K.

**(Total for Question 1 = 9 marks)**

**ResultsPlus**
**Examiner Comments**

This candidate states the trend very clearly for the first mark. They then quote data and miss the point that the shape of the graph is non-linear.

## Question 2 (a)(i)

**2** (a) Figure 3 is a speed limit sign from a European motorway.

The speeds shown are in km/h (kilometres per hour).

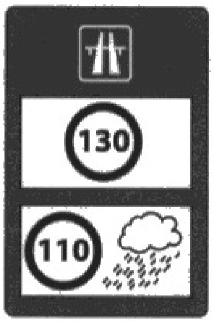



**Figure 3**

(i) The sign tells drivers to drive at a slower speed in wet weather.

Explain why it is safer for drivers to drive at a slower speed in wet weather.

**(2)**

If the weather is wet, it means that the road will be wet, which means less friction which therefore means it will take longer to brake and that it's possible the car could skid.

**ResultsPlus**
**Examiner Comments**

This candidate scores both marks. Firstly, they identify 'less friction', and secondly the consequence that 'it will take longer to brake'.

The specification majors on the idea of stopping distance and it is hoped that candidates would focus on this. 'Longer to brake' was accepted in additional guidance.

**ResultsPlus**
**Examiner Tip**

The specification can guide you. Point 2.29 says 'Explain that the **stopping distance** is affected by a range of factors . . .'.

In questions like this make stopping distance the focus of your argument.

**2** (a) Figure 3 is a speed limit sign from a European motorway.

The speeds shown are in km/h (kilometres per hour).

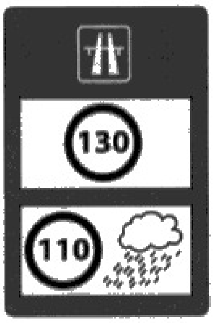



**Figure 3**

(i) The sign tells drivers to drive at a slower speed in wet weather.

Explain why it is safer for drivers to drive at a slower speed in wet weather.

**(2)**

Wet weather makes roads wet. Therefore ~~Skidding~~ ~~is mo~~ Sliding/skidding is more likely as the friction on the tires and the road is not high enough to stop as quickly when breaks

**ResultsPlus**
**Examiner Comments**

The candidate shows the correct idea about friction now being 'not high enough'.

The second mark may be earned from the reference to skidding (mark point 4 on the mark scheme) or the 'stop as quickly' comment (mark point 2).

## Question 2 (a)(ii)

going more brake time if your going slower

(ii) Show that a speed of 31 m/s is less than a speed of 130 km/h. **(2)**

1000m = km

31 x 60 = 1860m = 1 min

↳ x 60 = 1 hour

↳ 111,600

111600 ÷ 1000 =

111.6km

answer making it less.

ResultsPlus Examiner Comments

There were two possible routes taken to answer this question:

- either convert 31 m/s to km/h
- or convert 130 km/h to m/s

This candidate chooses the first route effectively.

Full marks are obtained.

is less. Wet road would increase braking distance so more dangerous.

(ii) Show that a speed of 31 m/s is less than a speed of 130 km/h.

**(2)**

130 ÷ 3600 = 0.0361 × 1000

= 36.1

~~36.1 m/s is larger~~

31 m/s is less than 36.1 m/s

÷1000

1000m = 1km

×1000

ResultsPlus Examiner Comments

This candidate converts 130 km/h to 36.1 m/s.

The mark scheme allows for intermediate marks if the evaluation goes awry.

Either converting km to m or converting h to s could get that intermediate mark.

## Question 2 (a)(iii)

(iii)

> The driver's reaction time is the time between the driver seeing an emergency and starting to brake.

A car is travelling at a speed of 31 m/s.

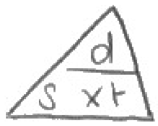
The car travels 46 m between the driver seeing an emergency and starting to brake.

Calculate the driver's reaction time.

Give your answer to 2 significant figures.

**(3)**

Speed = distance ÷ time




46 ÷ 31 = 1.5

driver's reaction time ........1.5........ s

**ResultsPlus**
**Examiner Comments**

Most candidates were able to achieve full marks on this question.

This may be achieved using the formula rearranged or the equivalent use of the memorisation triangle, which the candidate uses here.

The third mark was gained through citing correct significant figures at the end.

Some candidates forgot to do that, leaving their answer as 1.48 s and a few truncated that answer to 1.4 s, limiting them to 2 marks.

## Question 3 (a)(i)

**3** (a) (i) An aircraft starts from rest and accelerates along the runway for 36 s to reach take-off velocity.

Take-off velocity for this aircraft is 82 m/s.

Show that the acceleration of the aircraft along the runway is about 2 m/s².

Assume the acceleration is constant.

Acceleration = change in velocity ÷ time taken **(2)**

82 ÷ 36s

82 ÷ 36 = 2.2$\dot{7}$

**ResultsPlus**
**Examiner Comments**

This was a straightforward calculation. The vast majority of candidates were able to get full marks on this question.

## Question 3 (a)(ii)

(ii) Calculate the distance the aircraft travels along the runway before take-off.

Use the equation

$$v^2 - u^2 = 2ax$$ **(3)**

$$\frac{v^2 - u^2}{2a} = \frac{2ax}{2a}$$

$$\frac{v^2 - u^2}{2a} = x$$

$$\frac{(82)^2 - (0)^2}{2(2.27)}$$

distance = ~~1681~~ 1476 m

**ResultsPlus Examiner Comments**

Full marks obtained using 2.27 m $s^{-2}$ from previously.

(ii) Calculate the distance the aircraft travels along the runway before take-off.

Use the equation

$$v^2 - u^2 = 2ax$$

**(3)**

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

$82^2 \quad 0^2 \quad 2$

$$\frac{v^2 - u^2}{2 \times a \times x}$$

$$\frac{v^2 - u^2}{2 \times a} \qquad \frac{82^2 - 0^2}{2 \times 2} =$$

distance = 1681 m

1681

ResultsPlus
Examiner Comments

Full marks obtained using the abbreviated 2 m $s^{-2}$ from (i).

Note that the mark scheme has ranges of marks to encompass the various possibilities of acceleration values that candidates might use.

(ii) Calculate the distance the aircraft travels along the runway before take-off.

Use the equation

$$v^2 - u^2 = 2ax$$

**(3)**

$32^2 - 0^2 = 2(2.27)x$

$6724 = 4.54x$

$1219.13 = x$ m

distance = 1219.13 m

**ResultsPlus**
**Examiner Comments**

This candidate scores 1 mark for the substitution.

The evaluation is wrong and they don't set out clearly the rearrangement to get that second intermediate mark.

Examiners cannot do the work for candidates in that regard.

**ResultsPlus**
**Examiner Tip**

Set out all your working to ensure you get intermediate marks in case you make a slip. Here the candidate would have got that by writing x = 6724 / 4.54

## Question 3 (a)(iii)

A minority of candidates scored the mark here.

Many did not fully explain eg answering ‘in case it needs more space’, begging the question ‘Why?’.

(iii) Suggest **one** reason why the length of the runway used is always much longer than the calculated distance that the aircraft travels along the runway before take-off.

**(1)**

Wind slowing down the aircraft to rate of. Or ~~found~~

ResultsPlus
Examiner Comments

The effects of wind (or weather) provides a valid reason.

(iii) Suggest **one** reason why the length of the runway used is always much longer than the calculated distance that the aircraft travels along the runway before take-off.

**(1)**

~~[illegible]~~ In case of an emergency break.

ResultsPlus
Examiner Comments

This was amongst other 'sensible suggestions' that were accepted.

This comes equivalent to mark point 1 'take off aborted'.

Spelling mistakes, as here in 'break', are not penalised.

## Question 3 (b)(i)

With ½ m $v^2$ calculations some candidates fell down on the squaring aspect, but the vast majority achieved success with this.

(b) (i) The aircraft lands with a velocity of 71 m/s.

The mass of the aircraft is $3.6 \times 10^5$ kg.

Calculate the kinetic energy of the aircraft as it lands.

**(2)**

KE = ½ × M × $v^2$

= ½ × 3.6 × $10^5$ × $(71)^2$

= 907,380,000

kinetic energy of aircraft = 907,380,000 J

**ResultsPlus Examiner Comments**

Full marks, a clear example.

(b) (i) The aircraft lands with a velocity of 71 m/s.

The mass of the aircraft is $3.6 \times 10^5$ kg.

Calculate the kinetic energy of the aircraft as it lands.

**(2)**

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

$= \frac{1}{2} \times 3.6 \times 10^5 \times 71^2$

$= 90738000$

$= 9.0738 \times 10^7$

kinetic energy of aircraft = $9.0738 \times 10^7$ J

**ResultsPlus**
**Examiner Comments**

Looks good but makes a power of ten error.

**ResultsPlus**
**Examiner Tip**

Missing out copying down one extra zero after the 8 has cost this candidate.

It is often safer to work in powers of ten on your calculator. Then copy that power of ten answer to the answer line.

## Question 3 (b)(ii)

The mark scheme enabled a lot of attainment here, with answers accepted in terms of heat / thermal energy.

Ideas of mechanical transfer and citing energy stores were infrequently seen.

(ii) When the aircraft has come to a stop, all the kinetic energy has been transferred to the surroundings.

Give **one** way that the energy has been transferred to the surroundings.

**(1)**

~~Thermal~~ Through heating due to friction causing thermal energy

**ResultsPlus**
**Examiner Comments**

This may score either mark point 2 (the friction reference) or mark point 3 (thermal reference).

## Question 4 (b)(i)

Very few candidates could describe the practical and the measurements needed to calculate momentum before and after the collision.

Understanding of momentum is weak.

Most candidates did not think of the impact of the sticky pads, and often said that the trolley would bounce back instead of sticking together. This candidate has realised they go on together.

(b) Students investigate conservation of momentum using two identical trolleys.

A card is then added to trolley A.

Some of the apparatus is set up as shown in Figure 4.

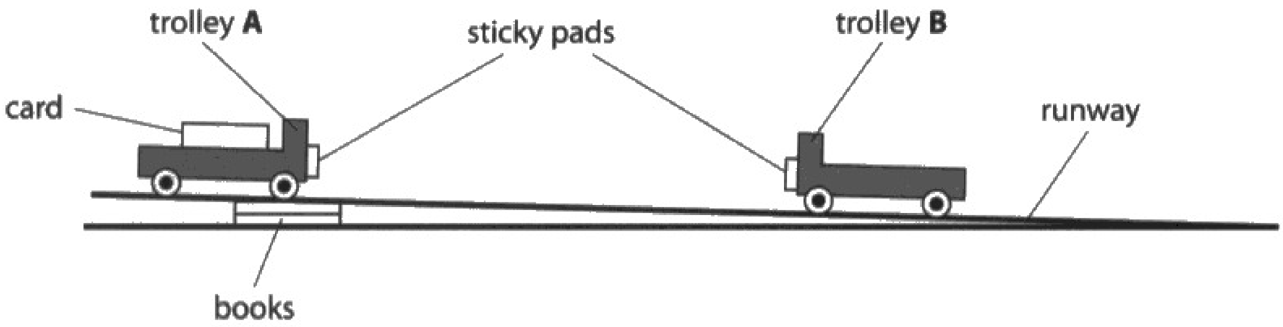



**Figure 4**

(i) Describe an investigation the students could carry out to show that momentum is conserved when these two trolleys collide.

You may add to the diagram to help with your answer.

**(4)**

- measure mass of trolley A and trolley B.
- measure distance between trolley A and trolley B (eg. from front wheel - trolley A to front wheel - trolley B)
- release trolley A and let roll down slope, record the time it takes to collide with trolley B.
- work out speed of trolley A ($s = \frac{d}{t}$)
- measure distance the 2 trolleys travel together after collision.
- work out initial and final momentum for both trolleys. (momentum = mass x velocity)

ResultsPlus
Examiner Comments

This is a well-constructed answer.

The candidate describes using distance – time measurements to obtain velocities. That is perfectly acceptable. Where candidates have knowledge of the use of light gates that is commended.

The mark scheme has 8 points, from which any 4 may accrue marks.

This answer scores on mark points 1, 2, 3, 4 and 6.

It achieves a maximum 4 marks.

## Question 4 (b)(ii)

Nearly all candidates believe the slope is there to give trolley A the speed or momentum it needs to collide with trolley B.

Extremely few got the mark, with some understanding of friction-compensation.

(ii) Give a reason for the runway being at a slope.

**(1)**

To compensate for frictional forces

**ResultsPlus**
**Examiner Comments**

Succinctly and perfectly put.

(ii) Give a reason for the runway being at a slope.

**(1)**

so trolley A moves down the slope at a constant speed when repeating the test

**ResultsPlus**
**Examiner Comments**

This scores mark point 2. The realisation that the aim is to get constant speed down the slope is very acceptable.

## Question 4 (c)(i)

This question involved calculating force from the change of momentum of a tennis ball, with the sign of the velocity before/after being key. Full marks, therefore, were extremely rare. The vast majority of candidates scored 0 or 1. Very few candidates spotted that they had to convert the time (milliseconds involved).

(c) Figure 5 shows a racket and a tennis ball.

The tennis ball is travelling towards the racket at a velocity of 8.2 m/s.

The ball is hit back in the opposite direction at a velocity of 15 m/s.

The ball has a mass of 0.075 kg.

The ball is in contact with the racket for 12 ms.

(i) Calculate the average force exerted by the ball on the racket.

Use the equation

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

0.075 × 15 ~~×~~ 0.075 × −8.2

12 ÷ 1000 = 0.012

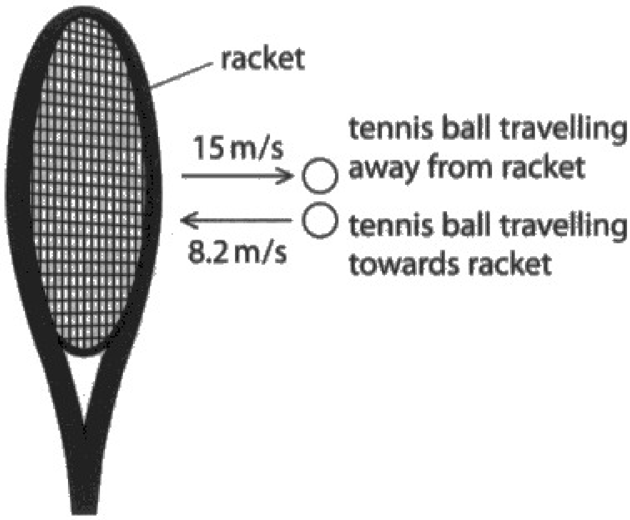



**Figure 5**

**(3)**

mass × final velocity = 0.075 × 15 = 1.125

mass × initial velocity = 0.075 × −8.2 = −0.615

$\frac{1.125-(-0.615)}{t}$ $\frac{1.74}{0.012}$ = 145

force = 145 N

ResultsPlus
Examiner Comments

This candidate sets out their working in a way that may be easily followed.

The realisation that the sign of the velocity matters is clear to see.

The calculation of change in momentum divided by time is clearly evident as well.

Finally 12ms have been correctly converted to 0.012s.

ResultsPlus
Examiner Tip

Velocity is a vector, as is momentum. So you can't ignore the direction things are travelling in.

The candidate sees velocity to the right as positive, and velocity to the left as negative.

Notice the way they set out the conversion of ms to s.

Small steps, clearly set out, can earn intermediate marks.

## Question 4 (c)(ii)

Showing knowledge of Newton's third law could readily earn the full 2 marks. Only a half of candidates could do that fully.

Only a few candidates tried to apply the law to this situation, which was really what was asked for.

(ii) Describe how Newton's Third Law of Motion applies to the collision between the racket and the ball.

**(2)**

The force that is exerted by the ball on the racket, is the same but opposite from the racket. This means that if the ball hits the racket with a force of 5N, the racket will return the 5N but in the other direction.

**(Total for Question 4 = 11 marks)**

ResultsPlus
Examiner Comments

This is a good example of how to approach the question with a response that 'applies to the collision between the racket and the ball'.

(ii) Describe how Newton's Third Law of Motion applies to the collision between the racket and the ball.

**(2)**

Newtons Third law means that the force exerted by the ball onto the racket is equal in magnitude and opposite in direction to force that the racket exerts on the ball, being a pair of action-reaction forces.

ResultsPlus
Examiner Comments

Again well applied.

(ii) Describe how Newton's Third Law of Motion applies to the collision between the racket and the ball.

**(2)**

Because every force has an equal in size reaction force and an opposite direction reaction force. The force arrows are equal in size and opposite directions

**ResultsPlus Examiner Comments**

This was typical of an answer that scored 2 marks for the general statement.

One mark for equal and one for opposite.

**ResultsPlus Examiner Tip**

Mark schemes may not always be as generous as this.

You should aim to apply your knowledge to the case at hand.

## Question 5 (a)

Most candidates scored 0 marks on this question.

Some made progress, but invariably did not know how to handle nanometres.

Candidates were sorely lacking in appreciating a plausible 'number of atoms'.

**5** (a) Rutherford devised an experiment to fire alpha particles at thin gold foil.

It was found that alpha particles were scattered by the gold foil.

The gold foil was about $4.0 \times 10^{-7}$ m thick.

A gold atom has a diameter of about 0.15 nm.

Estimate how many gold atoms would fit across this thickness of gold foil.

**(2)**

$4.0 \times 10^{-7}$ m = 0.4 micrometres

~~0.4~~ ÷ 1

0.4 x 1000 = 400nm

400 ÷ 0.15 = 2666.6 = 2667

number of atoms = ~~2666.6~~ 2667

**ResultsPlus**
**Examiner Comments**

This candidate can handle the units involved expertly, converting 4 x $10^{-7}$ m to nm via micrometres. So then dividing nanometres by nanometres gives the correct number.

**ResultsPlus**
**Examiner Tip**

'Nano' is one of a number of SI prefixes you should know.

It's in the 'Key concepts of Physics' (Topic 1) of the specification.

## Question 5 (b)(i)

Attainment here was appreciably greater than in Q05(a).

Wide tolerances in reading off the graph were allowed, permitting a half of all candidates to gain full marks.

(i) The number of particles detected at each angle in a given time is shown on the graph in Figure 7.

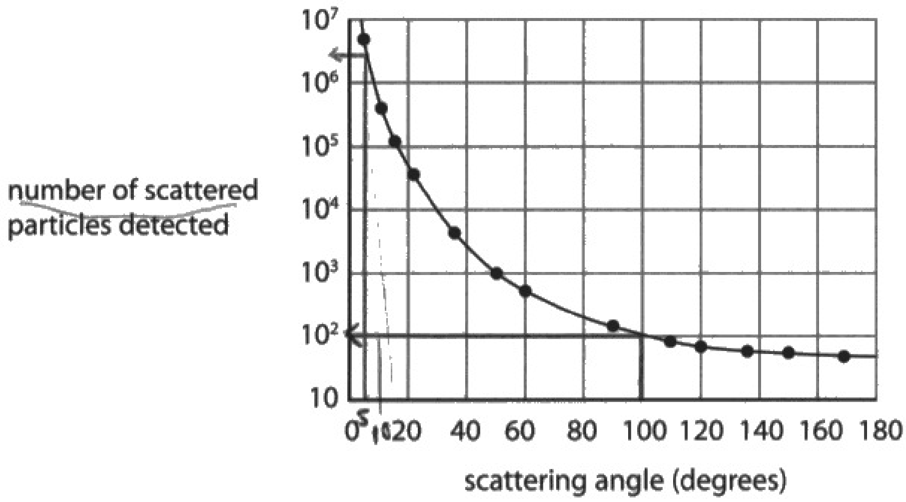



**Figure 7**

Use information from the graph.

Estimate the ratio of the number of particles scattered through 5° to the number of particles scattered through 100°.

**(2)**

$10^{6.5} : 10^{2}$

↓

~~3162277~~ : 100

ratio = $10^{6.5} : 10^{2}$

**ResultsPlus**
**Examiner Comments**

Clear working from the graph is seen.

The answer lies well within the tolerances set.

(i) The number of particles detected at each angle in a given time is shown on the graph in Figure 7.

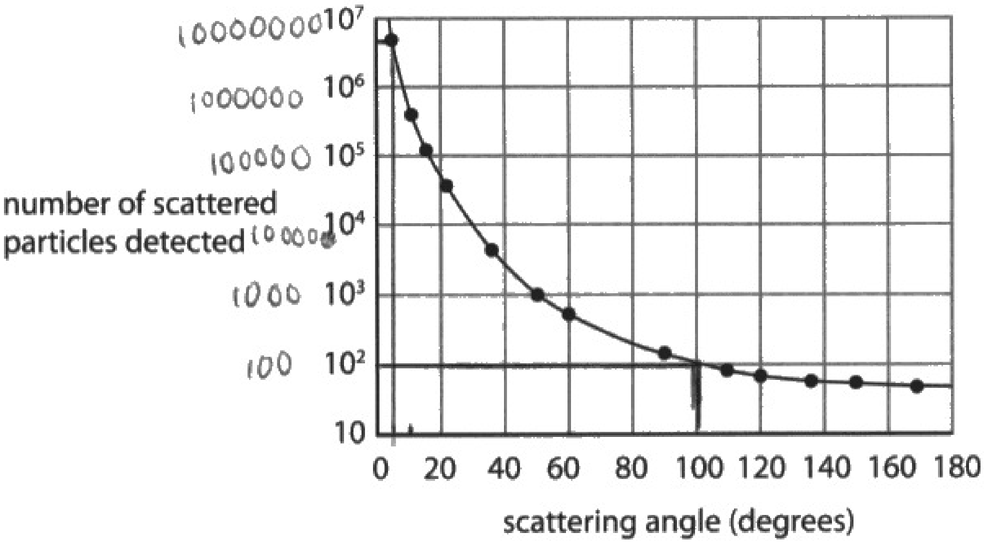



**Figure 7**

Use information from the graph.

Estimate the ratio of the number of particles scattered through 5° to the number of particles scattered through 100°.

**(2)**

$10^7 : 10^2$

10000000 : 100

100000 : 1

ratio = 100000 : 1

**ResultsPlus Examiner Comments**

It is equally acceptable to express the answer as 100 000 : 1.

Again, the working on the graph is quite clear to see.

## Question 5 (b)(ii)

This was an open response question of 4 marks. There was effective differentiation, especially for higher grades.

Most candidates were aware of the nucleus, with a large majority of these being able to describe a feature of it to earn another mark. However it was clear that many candidates were not familiar with this experiment and could not describe it.

Many were distracted by going into electron configurations (shells etc.)

**(ii) Explain how the difference in the number of particles scattered at different angles gives evidence for the current model of the structure of the atom.**

**(4)**

The current model of the atom is mostly empty space with a small positive nucleus. Most of the alpha particles would have passed through the space with little deflection due to not being in contact directly with the positive nucleus, but some would have hit the nucleus and been deflected or repelled by their positive charges.

**ResultsPlus**
**Examiner Comments**

To achieve marks any four from the six mark points could be credited. This candidate scores on mark points 1, 2, 4, 5 and 6, yielding the maximum of 4 marks.

(ii) Explain how the difference in the number of particles scattered at different angles gives evidence for the current model of the structure of the atom.

**(4)**

There is a small posotivley charged nuclias which wouldnt allow alpha particles through and would deflect them away but it's verry small so it only deflects to 5° unless it hits the middle. This shows the greater space is filled by electrons which is why we have large outer shells compared to nuclias.

**ResultsPlus**
**Examiner Comments**

This scores on mark points 5 and 6, in the opening two lines.

It fails to match any of the other mark points with clarity and ends with the electron shells distraction.

## Question 5 (c)(i)

Some candidates scored a mark for rolling the marble, with a few then going on to describe a method to measure the scattering.

(c) Students are given the apparatus shown in Figure 8 and a protractor.

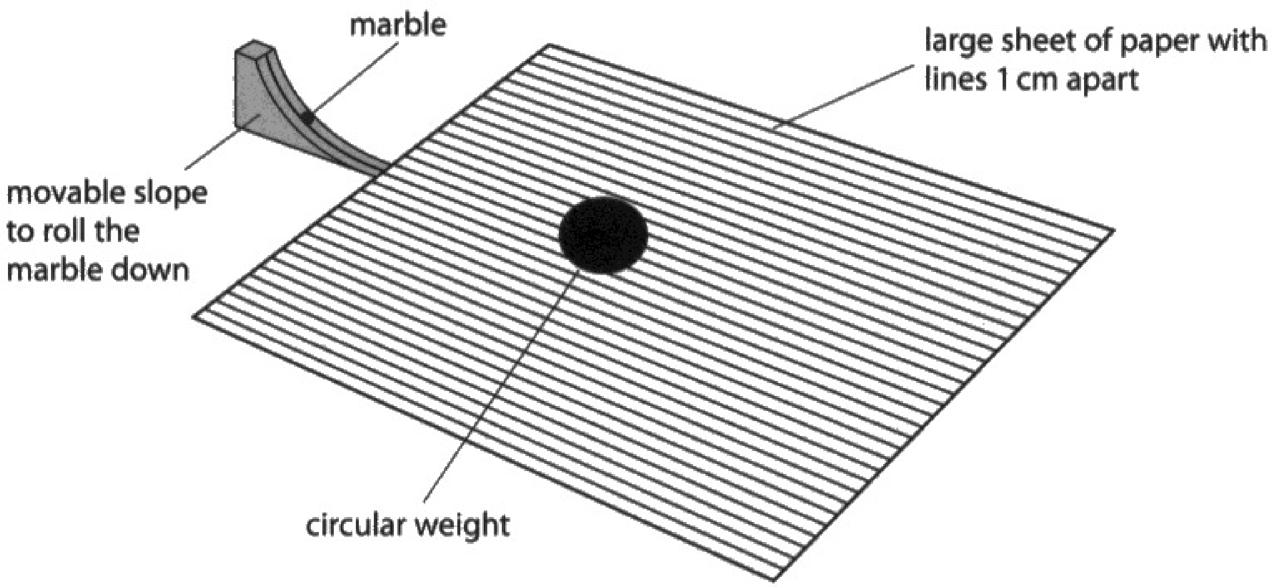



**Figure 8**

(i) Describe how the students could use the apparatus to model the scattering of alpha particles.

**(2)**

They could roll the marble down the slope at different points and mark where the marble stops each time on the paper to see a spread/scatter

**ResultsPlus Examiner Comments**

Roll the marble down (1st mark) mark where the marble goes (2nd mark).

(c) Students are given the apparatus shown in Figure 8 and a protractor.

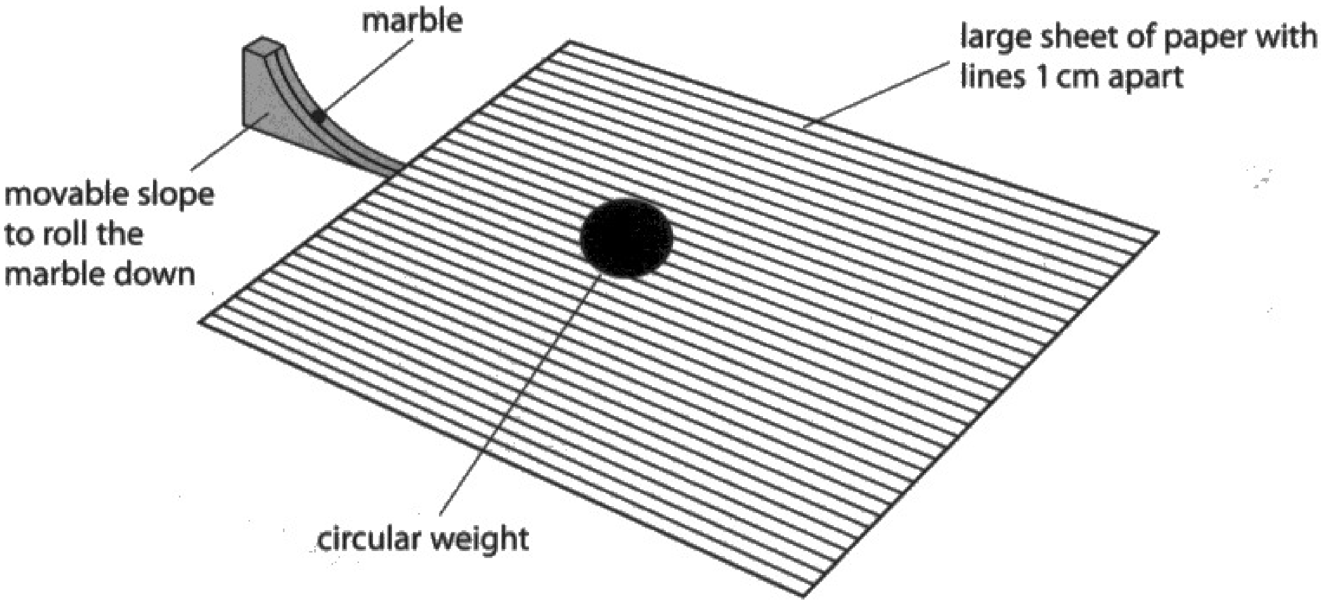



**Figure 8**

(i) Describe how the students could use the apparatus to model the scattering of alpha particles.

**(2)**

Use protractor to measure the degrees in which the alpha particles deflect.
see how many cm apart the deflections are.

ResultsPlus
Examiner Comments

This response is good regarding measurement but then lacks the basic instruction to roll the marble down in the first place.

ResultsPlus
Examiner Tip

Sometimes what you may think is obvious needs to be stated.

Ask yourself 'Could someone else perform this experiment by following my instructions?'.

Are your instructions complete?

## Question 5 (c)(ii)

It appears there is little understanding of the term ‘modelling’ in a scientific context. This is evidenced in such responses as “It has marbles when you’re meant to use alpha particles and a weight instead of a gold atom, there’s no fluorescent screen, so it’s nothing like the experiment at all”.

A number of candidates put vague answers about the model being “not accurate”.

(ii) Give **one** limitation of this model.

**(1)**

The weight and the marble are both not charged so cannot replicate how the nucleus has a positive charge, deflecting particles.

**ResultsPlus**
**Examiner Comments**

Matches mark point 1 on the mark scheme.

Note that the mark scheme is very broad allowing any one of seven possible ways of answering.

**ResultsPlus**
**Examiner Tip**

Models are like computer games. They are not the real thing but aim to 'replicate' aspects of the real world in a pretend version.

## Question 6 (b)(i)

The vast majority of candidates scored 2 marks out of 3 here.

They could rearrange the equation and substitute, but a lack of knowledge of "Giga" prevented all but a very few from gaining full marks.

(b) (i) A microwave oven uses waves of frequency 2.45 GHz.

Calculate the wavelength of the microwaves.

The velocity of light is $3.00 \times 10^8$ m/s.

**(3)**

$$\text{wavelength} = \frac{\text{wave speed}}{\text{frequency}}$$

$$\frac{3.00 \times 10^8}{2.45} = 122448979.6$$

$7.35 \times 10^8$

wavelength = .................................... m

**ResultsPlus**
**Examiner Comments**

The power of ten error still allowed 2 marks out of the 3 available.

**ResultsPlus**
**Examiner Tip**

Giga is one of the SI prefixes you are required to know – see Topic 1 of the specification.

(b) (i) A microwave oven uses waves of frequency 2.45 GHz.

Calculate the wavelength of the microwaves.

The velocity of light is $3.00 \times 10^8$ m/s.

**(3)**

wave speed = frequency x wavelength

3.00 x 10^8 m/s =

giga ↓ x1000
mega ↓ x1000
kilo ↓ x1000
standard

wave speed / frequency = wavelength

3.00 x 10^8 m/s / 2.45 GHz

x 1000 000 000

3.00 x 10^8 m/s / 2450000000 Hz = 6/49 = 0.122

wavelength = 0·122 m

ResultsPlus
Examiner Comments

This candidate scores all 3 marks, understanding the Giga prefix means x $10^9$.

## Question 6 (b)(ii)

This tended to be an either / or question.

Many candidates scored 0 marks and a good number scored 3 marks with very few getting the intervening marks.

There was significant mathematics demand; an input amount being asked for, given an output amount and the efficiency.

(ii) The microwave oven is 55% efficient and transfers 42 000 J of energy to some food when it is heated.

Calculate the total amount of energy that must be supplied to the oven.

**(3)**

total energy = $\frac{\text{useful energy}}{\text{efficiency}}$

$= \frac{42,000}{55}$ ~~×100~~ ⇒ 763.63

energy supplied to oven = 763.6 J

**ResultsPlus**
**Examiner Comments**

2 marks out of 3.

Missing converting the 55% to 55/100 resulted in missing a mark.

(ii) The microwave oven is 55% efficient and transfers 42 000 J of energy to some food when it is heated.

Calculate the total amount of energy that must be supplied to the oven.

(3)

55% = ~~4~~ 42000

$\frac{42000}{55} = 763.63$

763 × 100 = 76 363.63

energy supplied to oven = 76 363 J

**ResultsPlus**
**Examiner Comments**

Full marks, showing mathematical competence.

(ii) The microwave oven is 55% efficient and transfers 42 000 J of energy to some food when it is heated.

Calculate the total amount of energy that must be supplied to the oven.

**(3)**

$$\left(\frac{42000}{55}\right) \times 100$$

$= 76363.63$

energy supplied to oven = 76363.63 J

ResultsPlus
Examiner Comments

Full marks, showing mathematical competence.

(ii) The microwave oven is 55% efficient and transfers 42 000 J of energy to some food when it is heated.

Calculate the total amount of energy that must be supplied to the oven.

**(3)**

efficieny = ~~was~~ usful energy tranferred by device / total energy supplied

energy supplied = usfal energy / efficiency

energy supplide = 42000 / 55% = 23100

energy supplied to oven = 23100 J

**ResultsPlus**
**Examiner Comments**

This gets the selection and substitution mark, as well as the rearrangement mark.

It just falls down on the final calculation.

## Question 6 (c)

Almost all candidates were able to access Level 1 if they wrote something about the two wave types, notably regarding their uses.

A fair number of candidates were able to answer at Level 2; comparisons were usually made about either the comparative danger, or the wavelength / frequency to earn credit.

To achieve level 3, candidates needed to talk reasonably about ***the production of the waves***. That was the key deal breaker.

*(c) X-rays and radio waves are part of the electromagnetic spectrum and have different uses.

These radiations are produced in different ways.

X-rays are emitted when electrons within an atom go through energy changes.

Radiowaves are produced by electrons in circuits.

Compare X-rays with radio waves.

Your answer should refer to

- the uses of both types of radiation
- the different ways that electrons are involved in producing X-rays and radio waves.

**(6)**

X-rays ~~are the~~ have the second highest frequency in the EM spectrum, and subsequently have the second smallest wavelength. Whereas, radio waves have the lowest frequency in the EM spectrum, but have the highest wavelength. These features make both waves ideal for their uses. X-rays are used in hospitals to ~~see~~ obtain an insight into internal injuries - furthermore, they are used in security systems in airports due to their high frequency. Whereas radio waves are used in communications and satellite communications due to their long wave lengths that can pass through the ionsphere. ~~Radio waves~~ X-rays are produced when an atom there are energy changes in atoms, this is when an atom ~~gains~~ loses energy through ~~absorption~~ electrons ~~being~~ moving down their shells and defined energy levels. Whereas radio waves are produced by oscillating electrons in a current - which then releases low frequency and long wavelength energy - which is radio waves.

**(Total for Question 6 = 13 marks)**

**ResultsPlus**
**Examiner Comments**

This is a model answer, well worthy of the full level 3 – 6 marks.

*(c) X-rays and radio waves are part of the electromagnetic spectrum and have different uses.

These radiations are produced in different ways.

X-rays are emitted when electrons within an atom go through energy changes.

Radiowaves are produced by electrons in circuits.

Compare X-rays with radio waves.

Your answer should refer to

- the uses of both types of radiation
- the different ways that electrons are involved in producing X-rays and radio waves.

**(6)**

X rays have a shorter wavelength to radiowaves. X rays are more ionising than radiowaves. Radiowaves are used for communication whereas ~~EM~~ X rays are used in medical procedures. Radio waves have a shorter fregnency than X rays. They both travel the same speed in a vacuum. They are both transverse waves. ~~X ray can cause mutations in DNA due to ionising whereas Radio~~ X rays are emitted when electrons go down in energy levels - they are due to radiation being absorbed by electron then it ~~releasing~~ emmiting the ~~radio~~ ~~radiowaves~~ EM waves ~~back~~ out. Radiowaves are produced by oscillating particles and things detecting the radiowaves. They are both produced by electrons.

**ResultsPlus**
**Examiner Comments**

Answers do not need perfection to gain 6 marks.

This is a clear level 3 answer, with very good ideas shown about the production of x-rays. Radio wave production is not as good but it doesn't need to be. Note the 'or' in the general additional guidance of the mark scheme.

*(c) X-rays and radio waves are part of the electromagnetic spectrum and have different uses.

These radiations are produced in different ways.

X-rays are emitted when electrons within an atom go through energy changes.

Radiowaves are produced by electrons in circuits.

Compare X-rays with radio waves.

Your answer should refer to

- the uses of both types of radiation
- the different ways that electrons are involved in producing X-rays and radio waves.

**(6)**

X-rays, which have a greater frequency than radio waves, are predominantly used in hospitals to see a person's bones as they can penetrate the skin but are absorbed by bone to create images of bone structure. Radio waves, with a shorter frequency, are primarily used in telecommunication like the broadcasting of radio programs. Furthermore, the production of an x-ray is caused by an electron in an atom becoming excited and being ejected out of the atom (which becomes a positive ion when the electron leaves) after going up through its energy levels. This contrasts the production of a radiowave as the electrons producing the radiowave remain in the circuit and are not ejected out. In addition, X-rays can be produced naturally whereas radiowaves are man-made.

**ResultsPlus**
**Examiner Comments**

A level 2 answer, limited by the lack of credible response regarding the production of the waves.

*(c) X-rays and radio waves are part of the electromagnetic spectrum and have different uses.

These radiations are produced in different ways.

X-rays are emitted when electrons within an atom go through energy changes.

Radiowaves are produced by electrons in circuits.

Compare X-rays with radio waves.

Your answer should refer to

- the uses of both types of radiation
- the different ways that electrons are involved in producing X-rays and radio waves.

**(6)**

X-rays can be used in medicine, as it penetrates through soft tissue, allowing doctors to see the bones of patients.

Radiowaves can be used for communication.

X-rays have high frequency, therefore if it gets exposed to someone too much it could lead to heath issue

radiowaves has low frequency meaning that it causes no serious harm to humans.

**ResultsPlus**
**Examiner Comments**

This has uses plus a good basic comparison. It matches level 2 very well, hence 4 marks.

It would need statement(s) about production to progress further.

*(c) X-rays and radio waves are part of the electromagnetic spectrum and have different uses.

These radiations are produced in different ways.

X-rays are emitted when electrons within an atom go through energy changes.

Radiowaves are produced by electrons in circuits.

Compare X-rays with radio waves.

Your answer should refer to

- the uses of both types of radiation
- the different ways that electrons are involved in producing X-rays and radio waves.

**(6)**

When using X-rays the electrons within an atom go through energy changes so you're able to visially see the inside of someones body. Whereas radiowaves are produced by electrons in circuits in which is why you continuously hear your music or your tv as it's going on a loop, the electrons are produced in circuit. X-rays create light energy, ^electricity and heat energy whereas radiowaves create sound energy.

ResultsPlus
Examiner Comments

The candidate repeats the stem of the question; that cannot be credited.

The tv comment enables some credit at level 1.

Scores 1 mark.

## Paper Summary

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 milli, nano and Giga.

Three questions assessed candidates' knowledge of practical procedures, namely Q1(b)(i) and Q1(b)(ii) concerning thermal insulation, Q4(b) concerning momentum conservation – this included an open response question attracting 4 marks and Q5(b) and Q5(c) about alpha particle scattering, including setting up a bench top model. The standard of answers on practical questions was variable with some candidates showing good procedural knowledge, whilst for others there was a clear lack of familiarity shown, especially with the momentum conservation investigation.

Candidates were hindered in achieving level 3 responses in the 6 mark answer through their lack of knowledge and understanding of how X-rays and radio waves are produced.

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. After the event evaluations are also useful, especially when reflecting about how the experiment could have been improved.
- pay attention to units. The use of wrong units causes candidates to miss out on some marks. A focus needs to be made on the use of metres, kilograms and seconds, as well as derived units eg the Newton or the joule, which requires metres, kilograms and seconds in calculations to end up with energy in joules. Candidates also need to know the standard prefixes eg nano, micro, milli, kilo, Mega etc.
- practice on handling powers of ten in their calculations. They should be able to use their calculators with number in standard form when needed. It often helps to put answers in standard form rather than risk writing too many or too few 000s in an answer.
- take note of the marks allocated to a particular question and respond with a corresponding number of points in their answer. Candidates should take opportunities, where they can, to use diagrammatic illustrations to aid and prompt their explanations.

## 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

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London WC2R 0RL.