Examiners' Report
January 2013

GCE Physics 6PH02 01

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January 2013

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Introduction

This unit builds on related areas at GCSE as well as introducing a number of new topics, such as quantum effects. The paper allowed candidates to demonstrate good progression from GCSE, as well as their developing understanding of the newer areas.

In general, performance was better in parts of questions related to Assessment Objective 1 as opposed to Assessment Objective 2. Within these Assessment Objectives, marks were obtained more easily where candidates were required to identify appropriate formulae and complete calculations, than where they were demonstrating knowledge of principles and applying them to new and familiar contexts.

As in previous papers, there were questions relating to standard phenomena, such as atomic spectra, photoelectric effect and standing waves, in relatively straightforward contexts and better responses might have been expected to these. The mark schemes for these tend to have the same general points each time, apart from a few context-specific points in particular questions, and they can be learned in outline as 'set pieces'.

As in previous series', there was some evidence of confusion between the production of atomic spectra and the photoelectric effect.

Section A Candidates' overall scores for section A correlated well with their total marks for the paper, with E grade candidates generally achieving 5 or 6 correct responses and those at A grade typically responding correctly to 9 or 10 questions.

Question	Percentage of correct responses	Correct response	Most common alternative
1	87	A	B
2	82	B	D
3	91	D	A/B
4	14	D	C
5	82	A	B
6	83	C	A
7	83	B	A
8	64	C	B
9	80	D	A
10	59	A	D

The majority of candidates responded correctly to most questions. The exceptions were questions 9 and 10, still with a good response rate, and question 4, which was answered correctly much more rarely.

The preferred incorrect responses to some of the questions give an opportunity to speculate about the reasons for the most common errors.

1. This was a straightforward question for most, but students getting this wrong and choosing B were choosing the volt rather than the ampere.

2. Those choosing D at least knew that speed is constant, but reversed the order of the spectrum.

4. The great majority got this question wrong, and most of them opted for C because, in the absence of the normal on the diagram, they used the printed value of the angle as the angle of incidence in the glass.

5 and 6. Most of the candidates who got these wrong erred by a factor of 1000 by ignoring the k in kV or the m in ms. There was no obvious tendency for candidates to get both wrong, which suggests this was carelessness, rather than a particular problem with SI prefixes, but also serves to remind the students to look at the data carefully.

Question 11

The majority of candidates gained marks for identifying diffraction and/or indicating that electrons have wave properties, even if only indirectly, for example by mentioning 'wave-particle duality' but not stating that it applied to electrons. The spelling 'defraction' was seen occasionally and not given credit. Some responses referred to the interference pattern formed, without acknowledgement of the underlying diffraction.

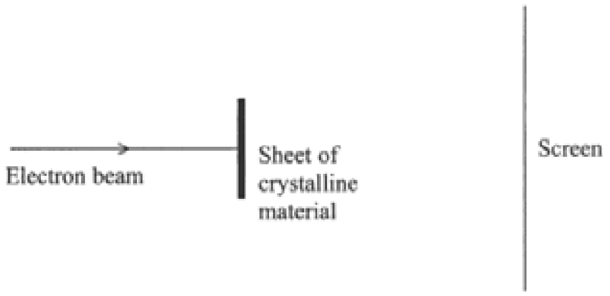
The third point, for relating the extent of the diffraction to the size of the electron wavelength relative to the obstacle, was seen much less often and awarded even less often because of imprecision in the response. An answer would typically refer to a 'gap the same size as the electron', rather than saying 'the interatomic spacing is the same size as the electron's wavelength'.

Other phenomena proposed included standing waves, the photoelectric effect and ripples caused by electron waves, as well as a suggestion that the picture represented orbitals, demonstrating particle behaviour due to scattering.

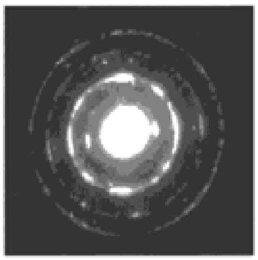
SECTION B

Answer ALL questions in the spaces provided.

11 The diagram shows a beam of electrons being fired towards a thin sheet of crystalline material. The screen detects electrons after they have passed through the sheet.



The photograph shows the positions at which electrons strike the screen.



Explain what can be deduced about the behaviour of electrons from the formation of this pattern.

(3)

They behave as particles,
They behave as waves.
They have be diffracted and refracted.
Electrons transfer energy.
Electrons are concentrated in the middle.

(Total for Question 11 = 3 marks)

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Examiner Comments

This is not the way to set out an explanation - it is just a list of facts. There is always the risk with a list that marks may be eliminated by incorrect answers.

When an explanation is required we expect some connection between the statements. E.g. the electrons show wave behaviour because they have been diffracted.

Whilst it is not possible to deduce some of these points from the pattern, the candidate has not been penalised in this case because the statements are not actually untrue, despite the ambiguity of the last point, and 2 marks have been awarded.

Explain what can be deduced about the behaviour of electrons from the formation of this pattern.

(3)

From the behaviour of the electrons we can see that they have "wave-like" properties and act like waves. This is because the pattern shows a pattern similar to that of light waves when they have been diffracted. The pattern shows that electrons can be diffracted by the sheet of crystaline as the size of atoms is similar to the electrons making a large focus of electrons in the centre and the diffracted electrons in the light outer rings.

(Total for Question 11 = 3 marks)

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Examiner Comments

The first two marks are clear, if not expressed succintly.

The candidate has attempted to link diffraction to the size of the waves and the size of the gap or obstruction, but has referred to the size of the electrons, rather than their wavelength.

ResultsPlus

Examiner Tip

Whilst there is no restriction on how much you may write, the space provided has been carefully judged to allow adequate room for a good answer. If you write too much you can 'talk' yourself out of marks.

Question 12

Most candidates recalled that resistance would be expected to decrease, but only about half mentioned an increase in charge carrier density. Half of those who did describe the change in n went on to complete the explanation, but often without direct reference to the equation mentioned specifically in the question. Others wrote about the effect of a fall in temperature. It has been said many times, but candidates should read the question carefully so that they can be sure to follow the specific instructions.

The third mark was most frequently awarded for linking a fall in resistance to a rise in current via $V = IR$. Mentions of A and q being constant were infrequent.

Quite a number of candidates thought that the increasing temperature increased v and therefore the current increased, since $I = nAvq$, so R decreased. This shows a complete misconception about the nature of drift velocity by confusing it with the random (thermal) motion of the electrons. Some candidates may need further help with moving on from the GCSE model of an orderly progression of electrons around a circuit, to an understanding of a drift velocity superimposed on the random motion of the electrons. A comparison of the typical velocities, such as mm per second versus km per second, could help to distinguish between them, and students should realise that the drift velocity is zero when there is no current but the random motion continues. The relationship between potential difference and drift velocity needs to be stressed, although this will be easier after the study of fields at A2.

12 A thermistor has a negative temperature coefficient. With reference to the equation $I = nqvA$, explain what happens to the resistance of the thermistor when its temperature increases.

(3)

When the temperature increases the resistance of the thermistor also increases. This can be explained with the equation $I = nqvA$, the cross-sectional area wouldn't change, neither would the charge of the charge carriers but the drift velocity and number of charge carriers would decrease and this would increase the resistance and so decrease the current.

(Total for Question 12 = 3 marks)

ResultsPlus

Examiner Comments

This response seems, in the first sentence, to treat the thermistor as a metallic resistor. Given that error, the rest of the answer has internal consistency in that it would decrease current and reductions in n and v would support this, but it has a major factual error. The reduction on v is expected, but it is not supported by a correct description of what happens to n, so no marks are awarded.

12 A thermistor has a negative temperature coefficient. With reference to the equation $I = nqvA$, explain what happens to the resistance of the thermistor when its temperature increases.

(3)

When temperature increases the electrons flowing through the resistor gain heat energy. ~~Als~~ ~~[illegible]~~ This energy is released by the electrons moving more quickly. As $I=nqvA$, and v = average drift velocity, this means the current increases. Equating this to $R=V/I$, because there is a higher current, resistance will fall.

(Total for Question 12 = 3 marks)

ResultsPlus
Examiner Comments

This is an example of a student confusing random motion of electrons with drift velocity. The candidate is still allowed a mark for the correct final conclusion.

12 A thermistor has a negative temperature coefficient. With reference to the equation $I = nqvA$, explain what happens to the resistance of the thermistor when its temperature increases.

(3)

~~A~~ NTC (negative temperature coefficient) thermistor decreases in resistance as temperature increases. The temperature heats the atoms so that more collisions take place however more electrons become free which over compensates leaving a net decrease in resistance.

(Total for Question 12 = 3 marks)

ResultsPlus
Examiner Comments

This answer is awarded 2 marks for the decrease in resistance and increase in *n*. A number of answers like this were seen, where the student considers both the effect of increased lattice vibration and the effect of increased charge carrier density and arrives at a sensible conclusion.

Question 13 (a)

About two-thirds of the entry identified a diode or LED. Other suggestions included thermistor, LDR, lamp, copper and resistor.

(a) State the name of the component. (1)

A ~~[illegible]~~ ~~[illegible]~~ a semi-conductor

ResultsPlus
Examiner Comments

Although the diode is made from semiconductor, this is not sufficient to name the component.

(a) State the name of the component. (1)

Filament lamp.

ResultsPlus
Examiner Comments

A typical incorrect answer. Along with the most common answer, thermistor, this does have a non-linear characteristic.

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Examiner Tip

Make sure you are familiar with the *I*-*V* characteristics of all the components named in the specification for either orientation of axes, as well as how to explain them.

Question 13 (b)

The most common answer by far, was zero, with infinity seen only about one time in four. Even candidates who had written *R* = 0.7 V / 0 A often stated zero as the answer. A few calculated the resistance for +0.7 V. Most were happy with this answer and did not consider the physical implication. They would have benefited from looking at the graph and considering that it shows zero current for all negative potential differences, meaning that the resistance is very large, not very small.

(b) State the resistance of the component when the potential difference is – 0.7 V. (1)

$\frac{-0.7}{0}$ = maximum

ResultsPlus
Examiner Comments

An example of a calculation with an incorrect answer.
Candidates sometimes have trouble multiplying by zero as well.

(b) State the resistance of the component when the potential difference is – 0.7 V. (1)

~~V=IR~~ $\frac{V}{I}$ = R, zero or undefined because current is zero and V=IR.

ResultsPlus
Examiner Comments

Another way to arrive at this incorrect result. This candidate may be aware that anything multiplied by zero is zero because 'undefined' is given as an answer.

ResultsPlus
Examiner Tip

It is always worth checking whether the Physics is consistent with a numerical answer. Zero is one answer here, but that would mean current was unhindered, not reduced to nothing.

Question 13 (c)

This calculation presented few difficulties, with the vast majority completing it successfully. A few tried to use the gradient of the graph and some misread the scale, but unit errors were rare in the answers.

(c) Calculate the resistance of the component when the potential difference is + 0.7 V.

(2)

$\frac{0.4}{0.7} = 0.57\,\Omega$

Resistance = $0.57\,\Omega$

ResultsPlus

Examiner Comments

The calculation is inverted here. Because the candidate has gone straight to this incorrect step, no credit can be given for use of the relevant equation. If *R* = *V*/*I* had been written down first, the candidate might well have substituted correctly.

ResultsPlus

Examiner Tip

It is always worth taking a moment to write out the relevant equation, rather than doing too much in your head at once.

(c) Calculate the resistance of the component when the potential difference is + 0.7 V.

(2)

$\frac{0.5 - 0.3}{0.72 - 0.68} = 5\ \Omega$

Resistance = $5\ \Omega$

ResultsPlus

Examiner Comments

This candidate has attempted to use the gradient of the graph to find the resistance. 0 marks

ResultsPlus

Examiner Tip

Resistance is defined as potential difference divided by current. It is not the gradient of a graph of potential difference against current. It only takes that value when the ratio is the same for every value on the graph - i.e. when resistance is constant and the graph is a straight line through the origin.

(c) Calculate the resistance of the component when the potential difference is + 0.7 V.

(2)

$V = IR$. $R = \frac{V}{I} = \frac{7}{0.4} = 17.5\ \Omega$.

Resistance = $17.5\ \Omega$

ResultsPlus

Examiner Comments

This gets a mark for 'use of' by substituting values of pd and current, but there is a power of ten error in the potential difference, so the final answer is wrong.

Question 13 (d)

In the majority of cases, a device that may contain a diode. Very often, a fire alarm was mentioned without stating the actual use of the diode in the device. Simple answers that gained credit just referred to the diode allowing current to flow in only one direction.

(d) State a practical use for this component.

(1)

In a phone battery.

(Total for Question 13 = 5 marks)

ResultsPlus
Examiner Comments

A typical answer naming an electronic device. This is not a specific use of the diode and it does not explain its function, if any.

(d) State a practical use for this component.

(1)

Using for some machine to only allow one direction for charge flow.

(Total for Question 13 = 5 marks)

ResultsPlus

Examiner Comments

An example of a correct answer.

Question 14 (a)

Only about a third of the candidates obtained this mark. Definitions were often imprecise. The answer needed to mention an electron, energy, and the surface of the metal. However, the last of those was usually missing and sometimes one of the other points as well. Other answers just said ‘the energy for the photoelectric effect to occur’. Some confused photoelectrons and photons and wrote about photons being emitted.

Candidates should expect to be asked to define terms such as this, and could prepare by learning the definitions. Others which typically appear in the examination are *energy level* and *photon*.

14 (a) Explain what is meant by the work function of a metal.

(1)

It is ~~an~~ the minimum energy required for the photo electric emission process.

ResultsPlus

Examiner Comments

This includes minimum energy correctly, but it then only refers to the photoemission process. As this could apply to any emitted photoelectron it does not include 'surface', but it is also not sufficient simply to name a process like this and leave it to the reader.

0 marks

14 (a) Explain what is meant by the work function of a metal.

(1)

work function is the minimum amount of energy needed to remove a photon from a metal surface.

ResultsPlus
Examiner Comments

This includes the references to the minimum energy and surface, but is about the emission of a photon. This may be a simple slip, writing photon instead of photoelectron, or it may be the result of a deeper misunderstanding.

ResultsPlus
Examiner Tip

Learn definitions thoroughly and be sure not to mix up technical terms which are similar, such as photon and photoelectron.

14 (a) Explain what is meant by the work function of a metal.

(1)

It is the minimum energy needed to release an electron from the metal.

ResultsPlus
Examiner Comments

No marks, because the response does not mention the surface.

Question 14 (b)

The 'scattergun' approach was adopted widely here, rather than a focused approach in response to the wording of the question. Often, it appeared that the question was glanced at, noting only the key words *photoelectric effect*, rather than being read fully. The presence of the asterisk, indicating a Quality of Written Communication (QWC) question, should have indicated that writing 'everything you know' about the photoelectric effect would not be sufficient. In QWC questions, marks are dependent on the response being organised in a logical manner, using appropriate technical wording,

Candidates lost marks because they did not, in most cases, identify a specific observation and linked points, in explanation. There were answers with multiple observations and others with multiple explanation points, but they were rarely linked. Although about two-thirds of the entry achieved at least one mark for a relevant point, only a quarter of them were awarded 2 or more marks out of 3 by linking the observation with an explanation. Some students just described the photoelectric effect in broad terms, sometimes in the context of a charged electroscope, and did not include enough detail for a single mark.

Although QWC requires a logical order, it is not the order of the statements as such, that matters but the way in which they are linked.

Increasing the intensity increases the number of electrons emitted per second, because a higher intensity means more photons per second and one photon releases one electron.

One photon releases one electron and a higher intensity means more photons per second, so increasing the intensity increases the number of electrons emitted per second.

A higher intensity means more photons per second, so increasing the intensity increases the number of electrons emitted per second because one photon releases one electron.

*(b) Observations of the photoelectric effect support the particle theory of light.

State **one** such observation and explain how it supports the particle theory of light.

(3)

The electrons rises to a higher energy level when it is heated in its atom. It rises to an unstable level and falls back to lower energy level emitting light. This observation supports the particle theory that particles can behave like wave and can release light when fall back to lower stable energy levels. When the particle falls to lower energy levels it can gives electromagnetic radiations, it could be ultra violet, infra red or light. Thermionic emmission takes place.

(Total for Question 14 = 4 marks)

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Examiner Comments

This response would receive two marks as the answer to a spectrum question. Unfortunately, the question is about the photoelectric effect and so the response scores nothing.

There are always some candidates who will confuse the photoelectric effect and spectrum production, possibly because they both involve photons and electrons and energy transfers between them.

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Examiner Tip

You must be clear about which situations involve the photoelectric effect and which involve atomic spectra. If you find yourself writing a similar response related to photons and electrons twice in a paper, you have probably chosen the wrong situation for one of them.

*(b) Observations of the photoelectric effect support the particle theory of light.

State **one** such observation and explain how it supports the particle theory of light.

(3)

~~The photoelectric effect when a metal surface is exposed is absorbed. and a electron is lost from the metal surface.~~

~~Extractions~~

Reference to E=hf or quanta of energy /packets of energy.

Increased f means more energy of photon.

Release of electron requires minimum energy

one photon releases one electron E = hf.

wave energy depends on intensity:

more intense light should give greater KE of electrons.

Energy is spread over the whole wave.

If exposed for long enough photons eventually released doesn't happen.

(Total for Question 14 = 4 marks)

ResultsPlus
Examiner Comments

This is an example of responses that were seen a number of times in this series but have not been common beforehand.

The candidate has memorised the mark scheme to a question in a previous examination and written it out. The first line makes it plain that each line is an instruction to a marker on what to award a mark for. Unfortunately for the candidate, the observations were in the question on that occasion and not in the mark scheme, so the maximum of 1 mark for a response without an observation is awarded for *one photon releases one electron*.

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Examiner Tip

Candidates are often advised to practise on old papers and compare their answers with the mark scheme. This is very useful for identifying weaknesses and priorities for further study. Be aware, however, that the context of questions will change so the answer one year is unlikely to match exactly the answer the next year. In addition, a mark scheme is a set of instructions to markers and does not always include a model answer - quoting the mark scheme may earn no marks at all.

*(b) Observations of the photoelectric effect support the particle theory of light.

State **one** such observation and explain how it supports the particle theory of light.

(3)

→ When a frequency above the f_0 ~~of~~ ~~a~~ wave is shone onto a metal (can be eg: Ultraviolet or Visible light), electrons are emitted ~~[illegible]~~ instantly.
→ Particle theory of light states that all the energy of a wave is concentrated into 1 photon. 1 electron will absorb this 1 photon and if the frequency is above or equal to the f_0 then the electron would instantly escape the metal

(Total for Question 14 = 4 marks)

6F

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Examiner Comments

2 marks for the instantaneous emission observation and the idea of one photon to one electron.

Question 15 (a) (i)

The great majority gave correct responses, but a few treated it as a parallel combination getting a result of 0.36 Ω.

(a) When the switch is closed:

(i) Calculate the total resistance in the circuit

$R_S = R_3 + R_2 = 0.2 + 0.2 = 0.4$ **(1)**

$\frac{1}{R} = \frac{1}{R_3} + \frac{1}{R_2} = \frac{1}{0.4} + \frac{1}{3.6} = 2.5\,\Omega$. $\therefore \frac{1}{R} = 2.5\,\Omega$.

Total resistance = $\frac{1}{R} = 2.5\,\Omega \;\therefore R = 0.4\,\Omega$

ResultsPlus
Examiner Comments

This response illustrates the parallel resistors approach, but it has not been completed correctly.

(a) When the switch is closed:

(i) Calculate the total resistance in the circuit **(1)**

$R_T = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{0.4} + \frac{1}{3.6} = \frac{25}{9} = \frac{9}{25} = 0.36\,\Omega$

Total resistance = $0.36\,\Omega$

ResultsPlus
Examiner Comments

The parallel approach completed correctly given the mistaken premise, but still worth no marks.

ResultsPlus
Examiner Tip

If there are no branch points in a circuit it is not parallel.

Question Q15 (a) (ii-iii)

Candidates very rarely missed the first mark for use of $V = IR$ and nearly all completed the calculation. About two thirds could use a power equation, although only about one in six calculated the correct power. Candidates usually used the resistance of the whole circuit, rather than the resistance of the heating element, and/or used a potential difference of 3.0 V, ignoring the effect of the internal resistance.

When there is a number of possible values for a given variable, candidates should take the time to consider the context very carefully so that they choose the correct values for their calculations.

(a) When the switch is closed:

(i) Calculate the total resistance in the circuit

(1)

$R_T = R_1 + R_2 = 0{\cdot}2 + 0{\cdot}2 + 3{\cdot}6$

Total resistance = 4Ω

(ii) Calculate the current in the heating element

(2)

$V = IR \rightarrow I = V/R \quad 3/4 = 0{\cdot}75$

Current = $0{\cdot}75\Omega$

(iii) Calculate the power output from the heating element.

(2)

$P = IV = 0{\cdot}75 \times 3$

$= 2{\cdot}25$

Power output = $2{\cdot}25W$

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Examiner Comments

This is a typical set of calculations with the correct values in the first part and the incorrect p.d. in the second. The unit is incorrect in (ii), so there is one mark for each part.

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Examiner Tip

Always be sure that the units match the quantity.

(a) When the switch is closed:

(i) Calculate the total resistance in the circuit

(1)

$3.6 + 0.2 + 0.2 = 4.0\ \Omega$

Total resistance = $4.0\ \Omega$

(ii) Calculate the current in the heating element

(2)

$R = \frac{V}{I} \Rightarrow \therefore RI = V \therefore I = \frac{V}{R} = \frac{3.0\text{V}}{4.0\Omega} = 0.75\text{A}$

Current = 0.75A

(iii) Calculate the power output from the heating element.

(2)

Power = VI ~~225~~

$= 3.0 \times 0.75 = 2.25$ Watts

Power output = 2.25W

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Examiner Comments

This is a more typical answer for 3 marks out of 4.

Question 15 (b)

About three-quarters of the candidates received at least one mark, usually for a decrease in current, but only half managed 2 marks and a small minority was awarded all 3. There were two possible explanations with linked power equations, but candidates often went wrong by mixing up total resistance and the resistance of the element, or by neglecting the effect of the internal resistance on the terminal potential difference.

In the first route, a mark was often missed by the absence of a statement that *total* resistance increased. Some linked an increased R, not actually the case for the element, to $P = I^2R$, to conclude that power increased. Others said $P = V^2/R$, so power decreases because resistance increases, whereas resistance remained at 3.6 Ω.

(b) When in use the internal resistance of each cell gradually increases.

State and explain the effect this will have on the power output of the heating element.

(3)

$P = I^2R$ so if the internal resistance increases this will cause an increase in the total resistance of the circuit. In $P = I^2R$ the increased resistance will cause an increase in the power output of the ~~circuit~~ heating element.

(Total for Question 15 = 8 marks)

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Examiner Comments

This example correctly identifies an increase in total resistance, but assumes that current is constant, ignoring the effect of resistance, and draws the wrong conclusion.1 mark

(b) When in use the internal resistance of each cell gradually increases.

State and explain the effect this will have on the power output of the heating element.

(3)

The internal resistance increases, the current will thus decrease, ~~as well~~ as well as the p.d. across the heating element will ~~also~~ also decrease, P= VI, the power output of the heating element will decrease.

(Total for Question 15 = 8 marks)

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Examiner Comments

This response is worth 2 marks by either route on the mark scheme, identifying a decrease in both current and terminal p.d. but not explaining why in either case, and then using $P = VI$.

Question 16 (a)

This is another standard definition which should be learned. The idea of only certain 'allowed' energies was not usually expressed clearly and only one in three got the mark, despite a helpful diagram on the page. The word 'discrete' appeared quite often, but rarely correctly in context. Frequently, there was no reference to electrons or atoms, or the position of the electron was considered to be the important factor. Imprecise answers like 'the energy an atom can have' were often given, and many answers referred to energy changes.

(a) State what is meant by an energy level.

(1)

The energy level is the energy required for making an electron excited.

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Examiner Comments

This candidate has linked energy levels to the energy of electrons, but has not used the idea of a restricted set of allowed energies.

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Examiner Tip

Learn the standard definitions.

(a) State what is meant by an energy level.

(1)

Location ~~on~~ of an electrons based on the amount of energy ~~to~~ it ~~possess~~ pocesses.

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Examiner Comments

No marks again. This is linked to a location and the amount of energy mentioned is not restricted in any way.

(a) State what is meant by an energy level.

(1)

Its the amount of energy needed for the electron to move from its level to the next

ResultsPlus

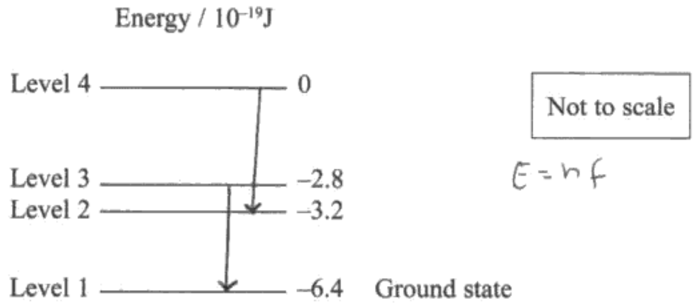
Examiner Comments

An example typical of responses about energy changes. That could be relevant, but not in this case, so no marks again.

Question Q 16 (b)

A reasonable majority of the candidates received both marks, with most getting at least one.

16 The diagram shows four energy levels for an electron in a particular atom.



(a) State what is meant by an energy level.

(1)

A discrete level of energy that an atom can occupy.

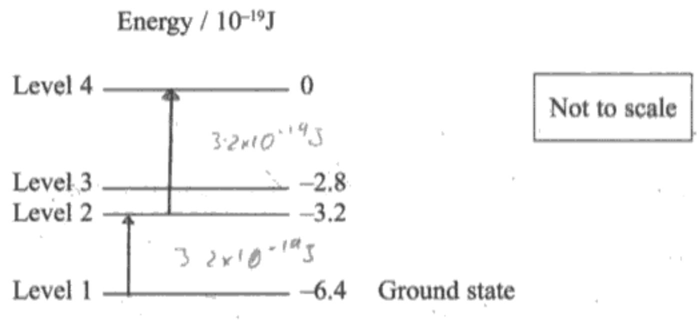
(b) Draw on the diagram **two** arrows to indicate two different transitions that would result in emitted radiation of the same frequency.

(2)

ResultsPlus
Examiner Comments

Right direction, but wrong levels. 1 mark

16 The diagram shows four energy levels for an electron in a particular atom.



(a) State what is meant by an energy level.

(1)

An energy level denotes how much energy would be released should an electron ~~[illegible]~~ jump between them.

(b) Draw on the diagram **two** arrows to indicate two different transitions that would result in emitted radiation of the same frequency.

(2)

ResultsPlus

Examiner Comments

Right levels, but wrong direction. 1 mark

Question Q 16 (c)

This was another 'set piece' answer which should be learned, but for which about only half of the candidates got two marks. The most common points mentioned were electrons going down levels and electrons moving up levels before this. The third point, when awarded, was usually for the release of energy as a photon, but many didn't link the photon to the energy released.

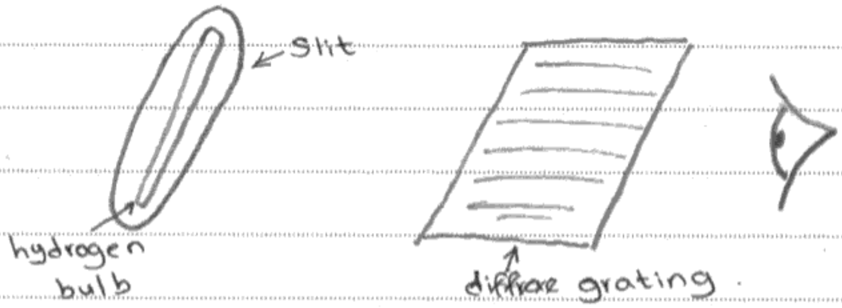
The actual line spectrum was rarely addressed. There was some confusion with the photoelectric effect, with occasional reference to work function.

(c) A gas consisting of these atoms can emit a line spectrum.

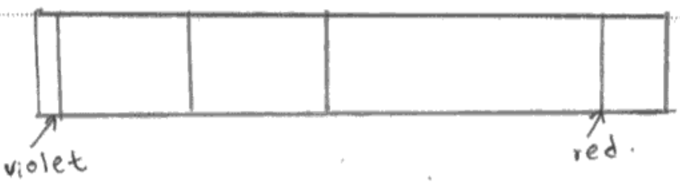
Explain how this happens.

(3)

lines spectrum is the electrons existing in different energy levels.



when we observe it through a diffrating grating.



ResultsPlus
Examiner Comments

This candidate misunderstood the question and tried to explain the practical procedure. The question asks how emission occurs, not observation. There are comments about energy levels, but not sufficient for any marks.

(c) A gas consisting of these atoms can emit a line spectrum.

Explain how this happens.

(3)

Electrons gain energy. ~~and~~
Move to higher energy levels.
Energy can calculate using E = hf
One photon release one electron.
Electrons move to different energy levels.

ResultsPlus
Examiner Comments

This response begins with spectra and moves into the photoelectric effect. It achieves a mark for the move to higher levels and a rather generous mark for the line about $E = hf$, although one might debate whether this has been applied in any sense.

(c) A gas consisting of these atoms can emit a line spectrum.

Explain how this happens.

(3)

· As the temperature is increased the electrons take in energy and move to higher energy levels.
· When these electrons fall back to their original energy level and release a photon as they do.
The wavelength of this photon corresponds with that of a colour of visible light so the photon emitted is a colour. This colour creates a line on the spectrum
If electrons fall from different energy levels many different wavelengths of photons are released so a spectrum of colours is produced.

ResultsPlus
Examiner Comments

2 marks were obtained in the first four lines.

The candidate would have received 3 marks with a the addition of a few words to make line 4 say 'release the energy as a photon'.

The rest tries to explain the actual spectrum, but without quite enough detail in lines 7 and 8.

Question 16 (d)

A large majority could select and use $E = hf$, but only a sixth identified the right energy difference to get the correct answer. They very often used the quoted Joules in part (d) and did not calculate a difference.

(d) One of these atoms in its ground state absorbs 3.6×10^{-19} J of energy from a collision with an electron.

Calculate the smallest frequency of radiation that the atom may subsequently emit.

(3)

$$E = hf = \tfrac{1}{2}mv^2 + \phi$$

$$hf = 3.6\times10^{-19}$$

$$f = \frac{h}{3.6\times10^{-19}}$$

$$= \frac{6.63\times10^{-34}}{3.6\times10^{-19}}$$

$$= 1.84\times10^{-15}\ \text{Hz}$$

Smallest frequency = 1.84×10^{-15} Hz.

ResultsPlus

Examiner Comments

No marks here. It starts off looking like the photoelectric effect but then moves to the right approach. The rearrangement of the formula is incorrect, however, and the substitution is after that, so no 'use of' mark is awarded.

(d) One of these atoms in its ground state absorbs 3.6×10^{-19} J of energy from a collision with an electron.

Calculate the smallest frequency of radiation that the atom may subsequently emit.

(3)

Energy emitted $= 6.4 \times 10^{-19} - 3.6 \times 10^{-19}$

$= 2.8 \times 10^{-19}$ J

$E = h.f \rightarrow f = \frac{E}{h} = \frac{2.8 \times 10^{-19}}{6.63 \times 10^{-34}} = 4.22 \times 10^{14}$ Hz

Smallest frequency = 4.22×10^{14} Hz

ResultsPlus

Examiner Comments

1 mark for the right method but the wrong energy.

Question 16 (e)

About four-fifths of the candidates identified the right calculation, but only half used the correct energy value.

(e) Calculate how much energy in eV would be required to ionise the atom in its ground state.

(2)

Energy $= 0 - (-6.4)$ eV $6.4\,eV \times 1.6 \times 10^{-19} = 1.024 \times 10^{-13}$ J

$= 6.4$ eV

Energy = 1.024×10^{-13} J

(Total for Question 16 = 11 marks)

ResultsPlus
Examiner Comments

No marks. This takes the values from the diagram, but converts the units to eV rather than J and completes the calculation consistently with that error, but not for this question.

(e) Calculate how much energy in eV would be required to ionise the atom in its ground state.

(2)

Charge of $1e^- = 1.6 \times 10^{-19}$ C $\cancel{E_v = 3.6 \times 10^{-19} \times 1.6 \times 10^{-19}\,C}$

$\cancel{1J = 1.6 \times 10^{-19}\,C}$ ∴ Energy $= \dfrac{3.6 \times 10^{-19}}{1.6 \times 10^{-19}\,C} = 2.25$ eV

Energy = 2.25 eV

(Total for Question 16 = 11 marks)

ResultsPlus
Examiner Comments

1 mark for correct method with an incorrect value in J to start with.

Question Q 17 (a)

The majority of candidates linked resistivity with a material, but only a quarter got both marks. Some said resistivity was a property of a wire instead of a material. Some said resistance depended on temperature, but so does resistivity, and some said that resistance depends on potential difference or on current. Some seemed to reverse resistance and resistivity, and some may have thought resistivity depends on length and area because of experiments such as that from 17 (b).

17 When tidying a prep room, a teacher discovers a tray of resistance wires that have lost their labels. She decides to ask her students to carry out experiments to determine the material that each wire is made of by measuring the resistivity of the wires.

(a) Explain why the teacher asks the students to measure the resistivity and not the resistance of the wires.

(2)

Because know the resistivity can calculate the resistance of the wires.

ResultsPlus

Examiner Comments

The candidate has some understanding in saying that resistance can be calculated from resistivity, but the reverse is also true and it does not have the required detail. 0 marks

17 When tidying a prep room, a teacher discovers a tray of resistance wires that have lost their labels. She decides to ask her students to carry out experiments to determine the material that each wire is made of by measuring the resistivity of the wires.

(a) Explain why the teacher asks the students to measure the resistivity and not the resistance of the wires.

(2)

The resistivity is constant for a particular material while the resistance for a material varies with current & voltage.

ResultsPlus

Examiner Comments

This example gets the resistivity mark, but not resistance because it is linked to p.d. and current, rather than dimensions.

Question 17 (b)

The great majority of candidates achieved at least 3 marks, over half at least 6, a third at least 7, but very few, 9. The question clearly identified the required points, for those who read it properly. The diagrams were usually satisfactory, although the wire was not always identified correctly. Some included power supplies with resistance meters. The need to measure length, current and potential difference was usually mentioned, although candidates sometimes only said 'take readings from the voltmeter and ammeter'.

The diameter measurement was not always included, with some seeking to measure cross-sectional area directly. Many candidates chose to plot graphs of *V* against *I*, using these to find resistance and effectively using only one length. A variety of possible graphs was used, including *RA* vs *l*, with the gradient giving the resistivity. The equation was usually rearranged correctly, but the use of the gradient was not always stated.

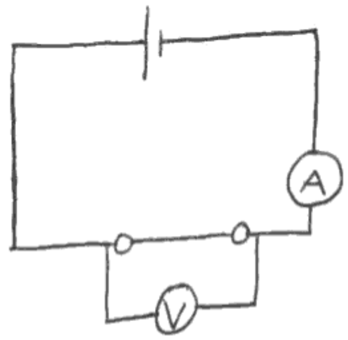
*(b) You are to describe a method to determine accurately the resistivity of one of the metal wires.

Your description should include:

- the circuit diagram you would use
- the quantities you would measure
- the graph you would plot
- how you would determine the resistivity.

(9)

$R = \frac{\rho l}{a}$, $\underline{\underline{\rho = \frac{Ra}{l}}}$



- You must measure:
- The length of each wire
- The cross-sectional area of each wire
- The voltage and current for each wire to find the resistance.
- Plot the values of voltage and curent on a graph and use them to ~~measure~~ determine the resistance using $R = \frac{V}{I}$
- using $p = \frac{Ra}{l}$, determine the resistivity of each material and write down your results.

ResultsPlus
Examiner Comments

This response receives marks for an acceptable diagram, 2 for measuring V, I and length and 1 for the final equation.

A graph is mentioned but not identified, the gradient is not referred to and it suggests that area can be measured directly.

5 marks

ResultsPlus
Examiner Tip

Be sure that you know the difference between what you can measure directly and what you can calculate from your measurements.

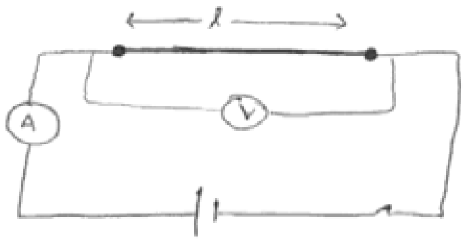
If you are using a graph, state the axes clearly, and identify the gradient and how you will use it.

*(b) You are to describe a method to determine accurately the resistivity of one of the metal wires.

Your description should include:

- the circuit diagram you would use
- the quantities you would measure
- the graph you would plot
- how you would determine the resistivity.

(9)



- Since 'R' = $\rho l / A$

∴ The length of the wire is needed, its ~~d~~ diameter; then we can the radius; then the area.

- The ammeter shows us the current flowing in the ~~cur~~ circuit and the voltmeter is ~~+~~ to find the Pd across the wire. Hence resistance is found.

- Now that everything is found the equation $\left(\rho = \frac{RA}{l}\right)$ is used to determine the wire's resistivity.

- A graph of 'R' against '$1/A$' can be drawn ~~$~~ and the gradient of the graph will be 'ρl'.

ResultsPlus
Examiner Comments

This is a good answer, but gets 7 out of 9 in the end.
because the calculation of cross-sectional area is not mentioned.
An interesting graph is proposed, and the gradient is identified, but the final step to go from gradient to resistivity is omitted.

Question 18 (a)

4 marks were rare, but nearly half got 3 or more and a majority got at least 2. The most common marks were for compressions and rarefactions and longitudinal waves, representing knowledge and understanding. The contextual interpretation was more difficult.

18 If certain crystals are subjected to a mechanical stress, a potential difference is generated across them. This is called the piezoelectric effect. These crystals can be produced as very thin films.

Below is a photograph of a T-shirt with a built-in phone charger, which is being tested at a music festival. The white rectangle is a piezoelectric film.

(a) By considering how a sound wave travels through the air, explain how sound can cause a piezoelectric film to generate a potential difference.

(4)

Sound travels ~~through~~ in air through compressions ~~a compression~~ and rarefactions. They travel ~~perpendi~~ parallel to the direction of motion. These compressions and rarefactions will cause mechanical stress to the crystals and therefore generating a potential difference due to the diffraction of sound waves into the thin films.

ResultsPlus

Examiner Comments

The final 2 marks were usually harder to obtain, but this example shows how it could be answered to gain those marks. There is another mark for compressions and rarefactions, but no mark for the most commonly seen point - longitudinal waves.

18 If certain crystals are subjected to a mechanical stress, a potential difference is generated across them. This is called the piezoelectric effect. These crystals can be produced as very thin films.

Below is a photograph of a T-shirt with a built-in phone charger, which is being tested at a music festival. The white rectangle is a piezoelectric film.

(a) By considering how a sound wave travels through the air, explain how sound can cause a piezoelectric film to generate a potential difference.

(4)

Sound wave is a longitudinal wave.
It's ~~motio~~ oscillations are parallel to the direction of motion, ~~therefere~~ therefore the air molecules vibrate causing compressions and rarefactions, this provides the mechanical stress on the crystals generating a potential difference across them.

ResultsPlus
Examiner Comments

An example of a full mark response, and it fits nicely in the space provided. Note the logical progression from point to point.

Question 18 (b)

About half received one or more marks, generally for suggesting a large area in a relevant context. The low energy levels of sound were mentioned very rarely indeed. Some tried to link the dimensions to the resistivity formula.

(b) Explain why the crystals used in the T-shirt need to be in the form of a large, thin film.

(3)

The crystals have to be in the form of a large, thin film so that the area increases, hence more sound waves are absorued and it should be thin to make it easy for absorbing the sound wave.

ResultsPlus
Examiner Comments

A typical one mark answer about a large area absorbing *more sound waves*. It is not clear how being thin helps with this.

(b) Explain why the crystals used in the T-shirt need to be in the form of a large, thin film.

(3)

large is order to absorb as much sound as possible therefore more stress and more P.D. and if it is thin it is more easy to bend and can therefore cause more P.D since it is stressed more easil..

ResultsPlus
Examiner Comments

A much less-common 2 mark answer. Most examiners did not see more than one or two references, if any, to the low energy of sound waves.

Question 18 (c)

A large majority of candidates could use the power equation and convert the energy and time to joules and seconds, but quite a few lost the last mark through rounding errors or giving the answer as a fraction.

(c) When the T-shirt is used at a music festival the sound levels are sufficient to generate about 20 kJ over ten hours. This is enough to charge one phone.

Calculate the electrical power output.

(3)

Power = $\frac{E}{T}$ => ~~20 000~~ $\frac{20\,kJ}{10\,hr}$ = ~~20~~ 2 kilowatt hour.

Power output = 2 kwh.

ResultsPlus
Examiner Comments

1 mark for use of power = energy / time, but the units have not been converted.

ResultsPlus
Examiner Tip

You should readily convert time in hours to seconds and deal with SI prefixes. Time would only normally be kept in hours in the context of kWh and possibly amp hours as a measure of the storage capacity of cells and batteries.

(c) When the T-shirt is used at a music festival the sound levels are sufficient to generate about 20 kJ over ten hours. This is enough to charge one phone.

Calculate the electrical power output.

(3)

$\frac{20\,000}{36000} = \frac{5}{9}\ \mathrm{Js^{-1}}$

Power output = ~~[illegible]~~ $\frac{5}{9}\ \mathrm{Js^{-1}}$

ResultsPlus

Examiner Comments

2 marks for 'use of' the equation and converting the units, but fractional answers such as this are not acceptable. It might be interesting to ask a class to discuss why 5/9 might be acceptable in Mathematics but not Physics.

(c) When the T-shirt is used at a music festival the sound levels are sufficient to generate about 20 kJ over ten hours. This is enough to charge one phone.

Calculate the electrical power output.

(3)

$P = \frac{20 \times 10^3}{10 \times 60 \times 60}$

$= 0.55\ W$

Power output = 0.55 W

ResultsPlus

Examiner Comments

2 marks only because of incorrect rounding. This has been truncated.

ResultsPlus

Examiner Tip

Always apply the normal rules for rounding.

Question 18 (d)

Most candidates received at least one advantage or disadvantage, even if they did not specify which was which, and half received both. Despite **one** in bold, some candidates gave multiple answers. They should be aware that it is not up to examiners to select the correct answer from a list and that inclusion of an incorrect answer will preclude the award of a mark.

Portability and long charging time were the most frequent responses, but poor expression sometimes meant a mark could not be given, e.g. 'doesn't need electricity' rather than 'doesn't need mains electricity'.

Vague answers about being 'environmentally-friendly', which would not receive a mark at GCSE, were very frequently given as advantages, whilst some were rather over-imaginative with disadvantages, suggesting overheating, electric shocks and even death.

(d) Give **one** advantage and **one** disadvantage of this charger compared with a conventional charger.

(2)

Advantage: Eco-friendly and economically beneficial. It doesn't cause any direct harm to the environment

Disadvantage: Power output/energy produced is less than a conventional charger.

(Total for Question 18 = 12 marks)

ResultsPlus

Examiner Comments

There is a clear disadvantage in the terms of the question, but *eco-friendly* is undefined and not necessarily supported, without knowing more about the manufacture and transport involved in producing the charger. 1 mark

(d) Give **one** advantage and **one** disadvantage of this charger compared with a conventional charger.

(2)

Sound charger is portable, therefore can charge the phone on the go.

D Time taken to fully charge the phone is very long.

ResultsPlus

Examiner Comments

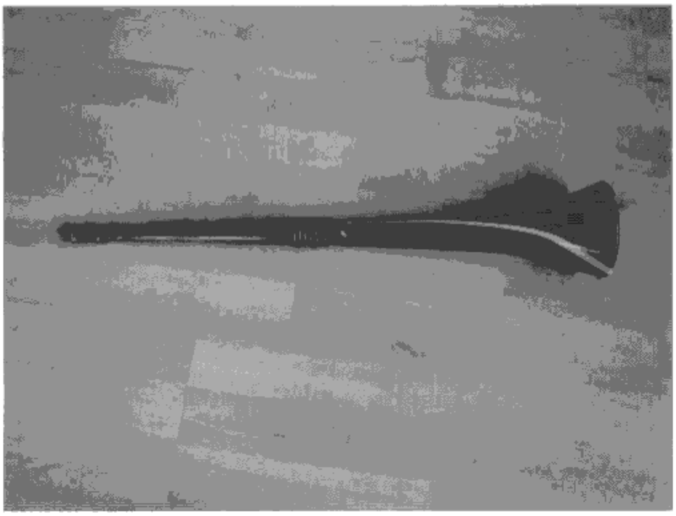
2 marks for the most common mark-worthy responses, if not always together.

Question 19 (a)

This was another standard explanation which did not even need information about the context. Whilst most candidates received at least one mark, a slim majority received two or more, and about a quarter, all three. Superposition was the least awarded mark, sometimes because the word 'superimpose' was used.

As with several other questions, this is an answer which should be learned as a standard response, to be adjusted for context when necessary.

19 The 2010 Football World Cup was held in South Africa and is remembered for the noise of the vuvuzelas.



The vuvuzela is a musical instrument which works by making the air inside the vuvuzela vibrate so that a standing wave is produced.

*(a) Explain how a standing wave is produced.

(3)

The progressive wave from the source meets the ~~reft~~ reflected wave and nodes and anti-nodes are formed as a result.

ResultsPlus
Examiner Comments

This response received two marks because superposition was not mentioned. Remember that if only two things are said and three marks are available, 3 marks will not be awarded.

ResultsPlus
Examiner Tip

Do try to make sure that there are sufficient separate points in the answer to match the marks available.

19 The 2010 Football World Cup was held in South Africa and is remembered for the noise of the vuvuzelas.

The vuvuzela is a musical instrument which works by making the air inside the vuvuzela vibrate so that a standing wave is produced.

*(a) Explain how a standing wave is produced.

(3)

when wave reflect back in ~~op~~ different direction of other one as they ~~from~~ come from same object they have same amplitude which doesn't change when they reflect when they hit each other a superpose is produce antinode (constructive interfence) and node (destructive interfence) are formed

ResultsPlus
Examiner Comments

This somewhat confused response was awarded 2 marks, for the 2 waves and the nodes and antinodes. The word 'superpose' appears, but the candidate says *they hit each other a superpose is produce antinode...* Whilst the right idea may be there, it is not expressed clearly enough to get the mark. This would apply to any question, not just QWC, because the point has not been made.

ResultsPlus
Examiner Tip

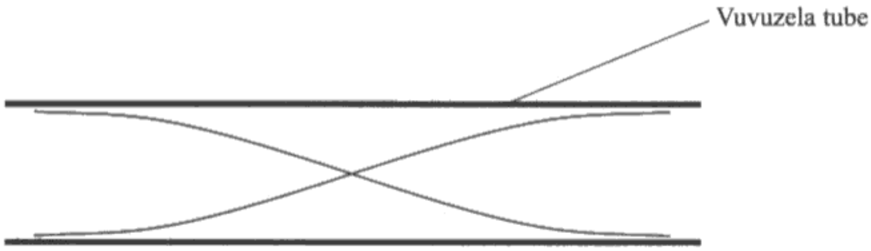
Marks are not just awarded for the use of key words.

Question 19 (b)

Identifying and using the wave equation eluded very few indeed, but only about a half thought to double the length of the tube to get the wavelength and a few of those left the result in cm.

(b) The vuvuzela makes a noise because it is producing standing waves of different frequencies.

The diagram shows the standing wave with the lowest frequency.



Calculate the frequency of this standing wave.

length of the vuvuzela = 60 cm = 0.6 m

speed of sound in air = $330\ \text{m s}^{-1}$

(3)

$f = \frac{v}{\lambda} = \frac{330}{0.6} = 550$

Frequency = 550 Hz

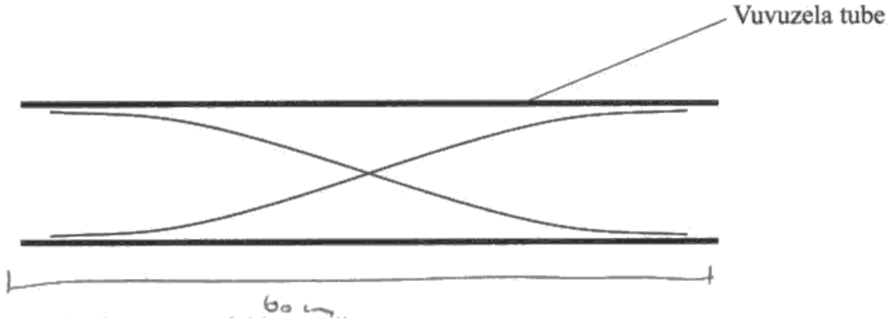
ResultsPlus

Examiner Comments

This gets the mark for use of the equation, but the value of wavelength is incorrect.

(b) The vuvuzela makes a noise because it is producing standing waves of different frequencies.

The diagram shows the standing wave with the lowest frequency.



Calculate the frequency of this standing wave.

length of the vuvuzela = 60 cm

speed of sound in air = 330 m s^{-1}

(3)

$\frac{1}{2}\lambda = 60cm \therefore \lambda = 120cm$

$v = f\lambda \quad f = \frac{v}{\lambda} \quad f = \frac{330}{120cm} = 2.75 Hz$

Frequency = 2.75 Hz

ResultsPlus
Examiner Comments

2 marks. The right wavelength has been used, but the value has been left in cm so the final answer is an incorrect match of magnitude and unit.

Question 19 (c)

Most of the candidates had a general idea of this, and could identify the correct frequencies to remove. However, they expressed the rest of the answer imprecisely and without sufficient detail in many cases. They often just said that there would be less noise or repeated the question to say that the commentators could be heard. The last marking point was most often missed because candidates misinterpreted the question as saying that all frequencies of sound were removed, not just those in the diagram. Even when they had the idea right, some did not state that the sound of the vuvuzela would be removed entirely but instead wrote of the atmosphere being spoiled or the noise of the crowd being removed.

f_1 f_2 f_3 f_4 f_5 f_6 f_7

Frequency

At the Football World Cup the noise of the vuvuzelas made it difficult for the television commentators to be heard. A solution was to use a filter that removed some of the frequencies produced by the vuvuzelas.

Suggest which **two** frequencies it would be best to remove, the effect this would have and the disadvantage of removing all of the frequencies.

(3)

Frequencies f_2 and f_3 because they have the highest amplitude and therefore produce the loudest sound. And if they are removed then commentators can be heard. If all the frequencies are removed the vuvuzela would be of no use.

ResultsPlus

Examiner Comments

This response received two marks. The statement about the commentators being heard is only a little more than has been implied by the question. It would be better to say that the commentators can be heard more easily or with less interference.

f_1 f_2 f_3 f_4 f_5 f_6 f_7

Frequency

↑ amplitude ↑ volume

At the Football World Cup the noise of the vuvuzelas made it difficult for the television commentators to be heard. A solution was to use a filter that removed some of the frequencies produced by the vuvuzelas.

Suggest which two frequencies it would be best to remove, the effect this would have and the disadvantage of removing all of the frequencies.

(3)

It is best to remove f_3 and f_7.

By removing these two frequencies, the sound the vuvuzelas produce would be reduced, hence enabling the commentators to be heard better. The disadvantage is that the vuvuzelas would be inaudible as well.

ResultsPlus

Examiner Comments

2 marks again. The descriptive part is an example of a very good answer for this question, but the wrong frequencies have been identified.

Question 19 (d) (i)

Most candidates received at least one mark, with half achieving at least two, the most common being for cancellation by destructive interference. Path difference and phase difference were very often confused and sometimes 'out of phase' was used to represent antiphase. Mention of equal frequency and amplitude was very rare.

(d) Noise cancelling headphones work by detecting a sound and producing another sound that is in antiphase and so causing destructive interference.

(i) Explain what is meant by antiphase and destructive interference.

(3)

- Antiphase is when two waves are out of phase, ie they do not trough and peak at the same point at the same time.

- destructive interference is when waves meet out of phase and the amplitude of the superimposed waves is the vector product of the two original amplitudes. When a peak & a trough are superimposed, destructive interference occurs & amplitude is zero.

ResultsPlus
Examiner Comments

One mark for zero amplitude at the end. Antiphase does not make a numerical reference and is just described as *out of phase*.

ResultsPlus
Examiner Tip

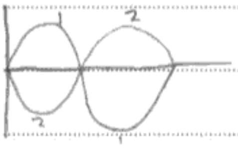
Never just say 'out of phase' when you mean 'antiphase'. Everything apart from 'in phase' is 'out of phase'.

(d) Noise cancelling headphones work by detecting a sound and producing another sound that is in antiphase and so causing destructive interference.

(i) Explain what is meant by antiphase and destructive interference.

(3)

Antiphase is when 2 waves are 90° ($\frac{\pi}{4}$ rad) out of phase.



The waves 1 and 2 are in antiphase, the sum of these waves at any point will (providing the are of equal amplitude) equal zero, completely cancelling out each other thus destructive interference.

ResultsPlus
Examiner Comments

This response receives both destructive interference marks, but refers to 90° for antiphase.

ResultsPlus
Examiner Tip

Learn about corresponding path and phase differences and be able to use both radians and degress to express phase difference.

Question 19 (d) (ii)

The mark was given to about three-quarters of the candidates, most often for saying the frequency or amplitude varied or that there are many frequencies.

(ii) Explain why the headphones could not be used to cancel the noise of the vuvuzelas.

(1)

The high pitch and frequency sound produced by vuvuzela proved impossible for the headphone to produce similar sound that is antiphase to cancel out each other.

ResultsPlus
Examiner Comments

An unsupported assumption has been made about the high frequencies. They are already being heard via a televison, so they must be reproducible by speakers.

(ii) Explain why the headphones could not be used to cancel the noise of the vuvuzelas.

(1)

The ~~vu~~ vuvuzelas have varying pitch and amplitude so are harder to match.

ResultsPlus
Examiner Comments

A sensible one mark answer.

Paper Summary

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

- The examination frequently includes questions about standard situations, such as standing waves, atomic spectra and the photoelectric effect. These require very similar descriptions and explanations each time, with only slight variations for context. Candidates should prepare 'set piece' answers for questions such as these, whilst taking note carefully of the particular context, so as not to answer a question from the previous paper instead of the current one.
- Candidates should note the available marks for a question before they start their answer. Then they can make sure that they have made a sufficient number of feasibly creditworthy responses to gain the marks. They may find that the use of bullet points helps with this.

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