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Examiners' Report
June 2016

IAL Physics WPH02 01

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June 2016

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Introduction

The assessment structure of Unit 2, Physics at Work is the same as that of Unit 1, Physics on the Go, consisting of Section A with ten multiple choice questions, and Section B with a number of short answer questions followed by some longer, structured questions based on contexts of varying familiarity.

The paper allowed candidates of all abilities to demonstrate their knowledge and understanding of Physics by applying them to a range of contexts with differing levels of familiarity.

Candidates at the lower end of the range could complete straightforward calculations involving simple substitution and limited rearrangement, including structured series of calculations, but could not always tackle calculations involving several steps, a choice of variables or extra factors. They also knew how to outline standard definitions, but often omitted key technical terms, and similarly knew the some significant points in explanations linked to standard situations, such as interference, but missed important details and did not always set out their ideas in a logical sequence, sometimes just quoting as many key points as they could remember without particular reference to the context.

Steady improvement was demonstrated in all of these areas through the range of increasing ability and at the higher end all calculations were completed faultlessly. Most definitions were given with all the required details and most points were included in ordered explanations of the situations in the questions.

Section A

The multiple choice questions discriminated well, with performance improving across the ability range for all items. Candidates around the E grade boundary typically scored about 5 and A grade candidates usually got 8 or more correct.

The percentages with correct responses for the whole cohort are shown in the table.

Question	Percentage of correct responses
1	82
2	82
3	46
4	41
5	42
6	49
7	64
8	41
9	12
10	47

Question 11 (a)

Candidates had little difficulty with this question, the great majority scoring both marks. Occasionally candidates lost a mark by not showing working clearly, as is required for a show that question, or by using 24 m s^{-1} as the speed.

(a) The speed of the water waves is 24 cm s^{-1} and the frequency is 20 Hz.
Show that the wavelength is about 1 cm.

(2)

~~v = f λ~~ speed of water wave = frequency x wavelength

$v = f \times \lambda$

$\lambda = \frac{v}{f} = \frac{24 cms^{-1}}{20 Hz}$ $\lambda = 1.2 m$

ResultsPlus
Examiner Comments

Although we don't insist on the unit for a 'show that' question, if it is given, the unit must be correct for the value. This scores one mark only for using the equation correctly.

(a) The speed of the water waves is 24 cm s^{-1} and the frequency is 20 Hz.
Show that the wavelength is about 1 cm.

(2)

$\lambda = \frac{V}{f} = \frac{2400 ms^{-1}}{20 HZ} = 120 m \div 100 = 1.2 cm$

ResultsPlus
Examiner Comments

This candidate has incorrectly converted the units of speed and corrected the answer to match the magnitude required by use of a factor of 100 without justification.

Question 11 (b)

Candidates typically scored 2 for this question, for recognising diffraction and for observing that diffraction increased with decreasing gap size or stating that it is at a maximum when gap size is equal to the wavelength. Many stated that there is no diffraction when the gap is smaller than the wavelength, despite diffracted waves being visible on the photograph. The mark for the first photograph was often not rewarded because the gap size was not compared to the wavelength.

(b) Explain what is shown by the sequence of photographs.

(4)

Diffraction of waves when they meet an obstacle. As the size of the gap decreases, diffraction of waves decreases.

When the gap is less than the wavelength, then there is no diffraction.

ResultsPlus

Examiner Comments

This candidate only gets one mark for identifying diffraction. It says diffraction decreases as gap size decreases. Note the common response that there is no diffraction when the gap is smaller than the wavelength.

(b) Explain what is shown by the sequence of photographs.

(4)

• In each photograph waves travel through a gap and spread out, which means diffraction occurs.
• When the gap is 7cm the diffraction occuring is ~~very less~~ almost none
• When the gap is 3cm very little diffraction occurs because gap is greater than the wavelength.
• As the wavelength and gap both are 1.2cm therefore the diffraction or spreading of waves is maximum in 1.2cm gap.
• At 0.1 cm gap the wave is unable to pass so no or very little diffraction is seen.

(Total for Question 11 = 6 marks)

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Examiner Comments

This answer gains credit for identifying the relevant phenomenon as diffraction and for describing the situation when the wavelength is less than the gap size. The pattern of change with decreasing gap size has not been described and the situation at 1.2 cm has not been related to wavelength.

The final sentence refers to 'no or very little' diffraction. Candidates cannot give two answers and hope the examiner will choose the correct one, although this would not have been enough for a mark even if it hadn't said 'no diffraction'.

(b) Explain what is shown by the sequence of photographs.

(4)

The amount of diffraction is effected by the size of gap. When the size of gap is equal the wavelength of water, the amount of diffraction is greatest. When the size of gap is much greater than the wavelength, the amount of diffraction is smaller than the gap size is 1.2 cm. When the size of gap is smaller than the wavelength, the amount of diffraction is still greatest but the intensity decreases. Diffraction means the wave spreads out into 'shadow region' when passes through a gap or around an obstacle.

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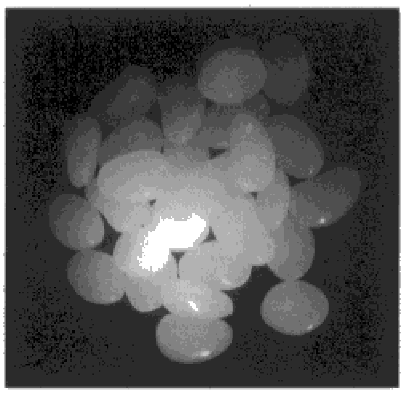
Examiner Comments

An example of a question gaining full marks.

Question 12

A majority of candidates scored at least 2 marks for this question, but they were limited by lack of detail even when they had the general idea. A lot of candidates applied the standard answers given for the photoelectric effect and there were many references to intensity, despite this not being part of the question, including statements that the red laser had the greatest intensity, the provenance for this assertion being quite unclear. Marks were often not awarded because of lack of further reference to photons or a failure to establish explicitly that violet has the highest frequency and therefore photons of the highest energy. When the wave part was actually addressed, the idea of energy building up was often expressed satisfactorily along with a statement relating to any frequency causing the effect.

***12** The photograph shows some toy 'glow-in-the-dark' stones. After being exposed to sunlight the stones glow, emitting light.



The packaging states that the stones work with any light source. A student tests this by illuminating the stones with light from a red laser, a green laser and a violet laser in turn. The red and green lasers have no effect on the stones, but the glow is seen immediately when the violet laser is shone on the stones.

The light produced by the lasers has the following wavelengths:

red = 650 nm
green = 530 nm
violet = 405 nm

$E = hf$ $v = f\lambda$. $f = \frac{v}{\lambda}$

Suggest how these observations could be explained by the photon nature of light but not the wave nature of light.

(5)

~~The photon nature of light~~ ~~When the~~ ~~The wave nature~~

When ~~light is sh~~ the stones are exposed to the light,

they absorb energy. When they absorb energy the ~~particles~~ electrons

in the stones will vibrate and get excited and 'jump to

a higher energy level. The electron will fall back to its original

energy level and will emit a photon which is the light seen

The difference between the 2 energy levels is the kinetic energy

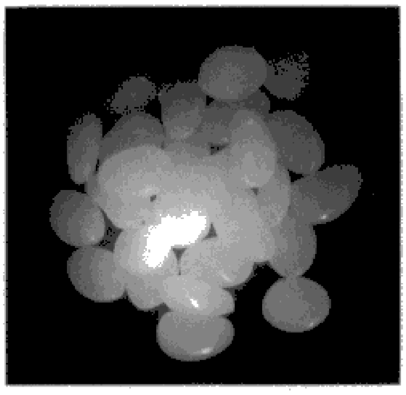
of the ~~light~~ electron. In order for the ~~light~~ electron to jump that energy levels, a specific frequency is needed, according to E = hf. This is explained by the photon nature of light. In the wave nature of light, it does not matter what the frequency or wavelength of the light is as the electrons will continue to absorb energy but this does not happen.

ResultsPlus
Examiner Comments

This gets both marks for the wave part of the explanation at the end of the response.

There is no comparison between the different coloured lasers, limiting the availability of further marks, so just one more mark is awarded for outlining the mechanism.

12 The photograph shows some toy 'glow-in-the-dark' stones. After being exposed to sunlight the stones glow, emitting light.



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Suggest how these observations could be explained by the photon nature of light but not the wave nature of light.

(5)

Photon is a discrete ~~amount of~~ packet of energy and one electron can receive only one photon at a time. Photons are of energy $E=hf$ so the higher the frequency the more energy per photon. This explains why violet of highest frequency (because of lowest wavelength since we have constant speed) will exceed what is known as the threshold frequency so will provide enough energy ~~[illegible]~~ $> \phi$ so the electrons are emitted. The wave nature of light does not explain this as we can see that energy does not accumilate as the red and green lasers have no effect and the ultraviolet has instant results.

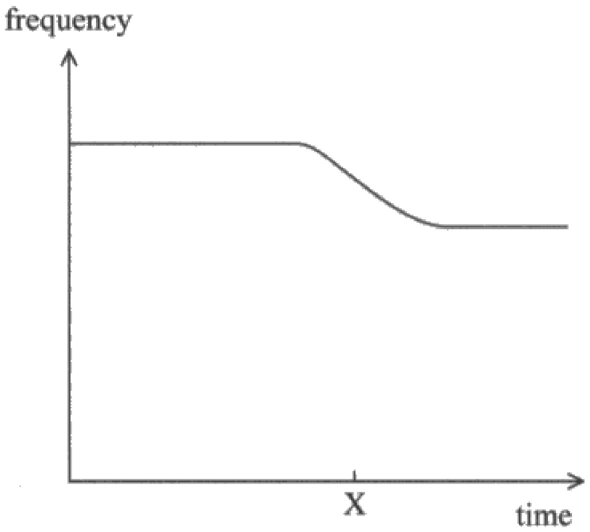
ResultsPlus
Examiner Comments
An example of one of the ways to obtain full marks. This doesn't discuss the mechanism in detail, but answers five of the seven possible points to get full marks for the question.

Question 13

Candidates too often started with the graph and did not visualise the situation set out in the written part of the question. They described a situation where there was only movement during the time where the graph was not horizontal and often linked the frequency directly to the distance of the car from the observer rather than its speed. Many others seemed to think that the command word was describe rather than explain as they just wrote about the frequency being high and constant, then decreasing and then being lower and constant with no accompanying explanation. Where students' descriptions correctly linked the frequency change to the direction of relative velocity, they did not often explain why the frequency changed in this way.

*13 A spectator at a motor race records the frequency of the sound he hears as a racing car drives past on a straight part of the track.

The graph shows how the frequency of the sound he hears varies with time.



The car passes the spectator at time X as shown on the graph.

Explain the shape of the graph.

(4)

when the car was near the speetator the frequerey was high and constant, but when it started to leave the side of speetator it frequerey gradually deereases, and then continued with less frequerey. upto point x the ~~graph~~ ~~is~~ line is straight because the frequerey was constant, and then the line move downward cause frequerey was decreasing and then again straight line cause the frequerey was again constant.

ResultsPlus
Examiner Comments

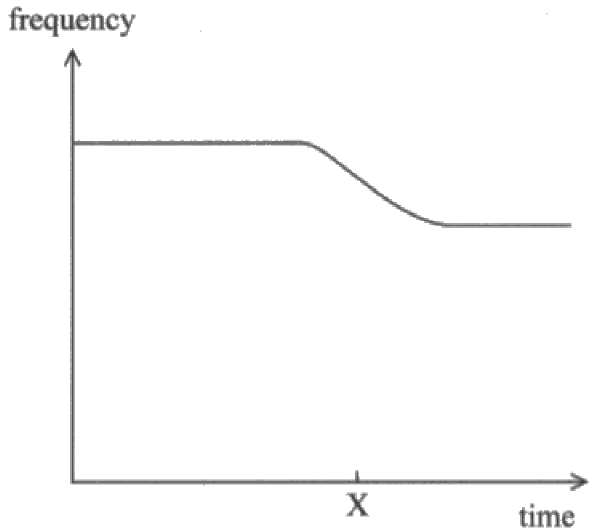
This only describes what can be seen on the graph and gets no credit.

ResultsPlus
Examiner Tip

Be sure you know the command words and understand the level of required response for each of them, e.g. explain here means the candidate must say why it happens and not just describe what happens.

*13 A spectator at a motor race records the frequency of the sound he hears as a racing car drives past on a straight part of the track.

The graph shows how the frequency of the sound he hears varies with time.



The car passes the spectator at time X as shown on the graph.

Explain the shape of the graph.

(4)

~~As the frequency on~~

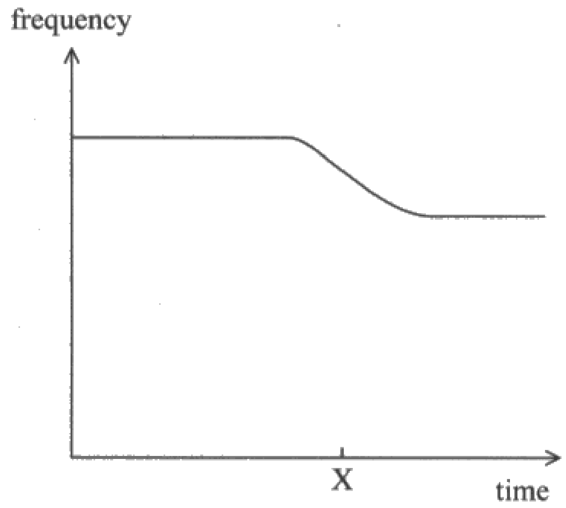
The shape of the graph is due to doppler effect - which is the apparent change in the wavelength of a wave ~~&~~ due to relative motion between a stationary observer & a moving object. when the sound comes near the listener the wavelength of the sound is ~~decreasing~~ greater, so the frequency is higher. when the sound is further away the wavelength is ~~too~~ higher so the frequency is less.

ResultsPlus
Examiner Comments

This gets one mark for identifying the Doppler effect and linking it to a wavelength change for a moving object. It then goes on to describe the change in frequency in terms of position rather than relative motion, so no more marks are awarded.

*13 A spectator at a motor race records the frequency of the sound he hears as a racing car drives past on a straight part of the track.

The graph shows how the frequency of the sound he hears varies with time.



The car passes the spectator at time X as shown on the graph.

Explain the shape of the graph.

(4)

the person is experiencing the doppler effect. Before X the car is moving towards the person. This causes an increase in the observed frequency. At X person experiences original frequency. As the car moves away, the observed frequency decreases.

ResultsPlus
Examiner Comments

This candidate has explained the graph in terms of the frequency changes caused by the Doppler effect for 3 marks.

Question 14 (a)

Only about a quarter of the entry determined the frequency correctly. One error was misinterpreting the prefix in μs and using an incorrect power of ten. Others got inaccurate answers by using a single cycle rather than the four cycles on the trace. Some attempted to apply the wave equation, believing they could use the graph to determine the wavelength. Another frequently seen method was based on using 1 ÷ 10 μs. Students did not remark on it when their answers were clearly outside the range of ultrasound.

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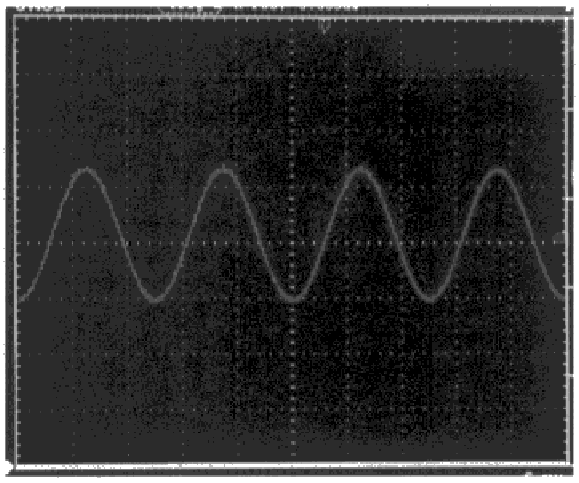
14 An ultrasound detector connected to an oscilloscope is set up near to an ultrasound emitter.

detector	emitter

The following trace is recorded.

Trace 1



(a) The time-base of the oscilloscope is 10 μs per division.
Determine the frequency of the ultrasound wave.

(2)

time period of wave = 10μs x 2.5

$= 10 \times 10^{-12} \times 2.5$

$= 2.5 \times 10^{-11}$

frequency $= \frac{1}{2.5 \times 10^{-11}} = 4 \times 10^{10}$

Frequency = 4×10^{10} Hz

ResultsPlus
Examiner Comments

This candidate has misinterpreted micro as x 10^{-12}.

ResultsPlus
Examiner Tip

Be sure you know the standard SI prefixes.

(a) The time-base of the oscilloscope is 10 μs per division.
Determine the frequency of the ultrasound wave.

(2)

3

$v = f\lambda$ $v = \frac{d}{s}$ $f = \frac{1}{T}$

$\frac{v}{\lambda}$ $f = \frac{1}{s}$

2.5×10^{-6} $= \frac{1}{25 \times 10^{-6}}$ $= 4000$ Hz

25×10^{-6}

Frequency = 4000 Hz

ResultsPlus

Examiner Comments

The measurement from the graph is correct, but an error has been made during the calculation. The candidate might have been expected to realise that 4000 Hz is not high enough to be classed as ultrasound.

ResultsPlus

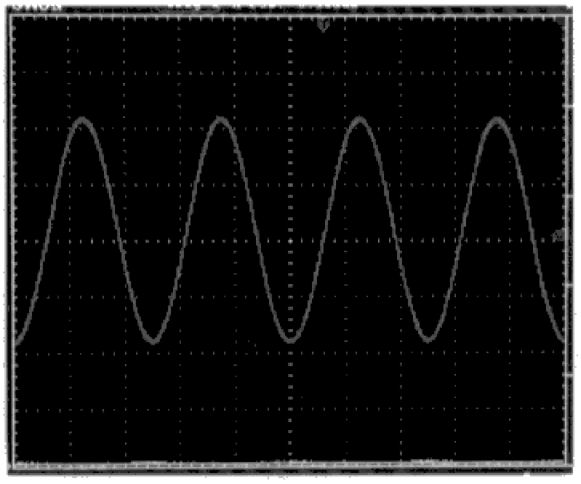
Examiner Tip

Compare your numerical answers to known real-life quantities when possible and go over your working if they don't make sense.

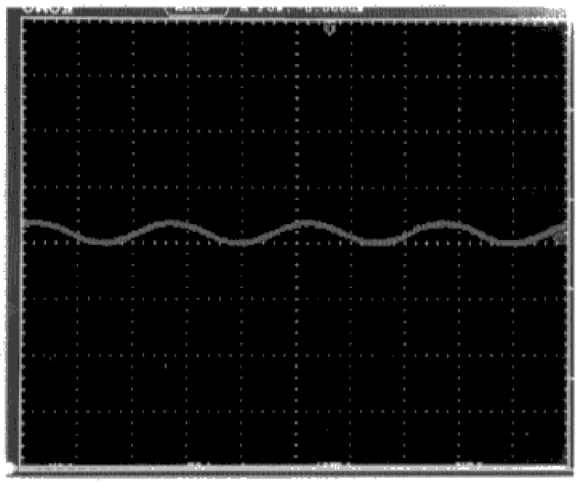
Question 14 (b)

A majority of answers scored at least half of the marks, illustrating a general appreciation of the relevant phenomenon but a lack of detail. Candidates scoring 3 typically omitted references to either phase or path difference and did not refer to amplitude. A recurrent error was to refer to phase difference as path difference or vice versa, e.g. the phase difference is nλ or the path difference is π. Others sometimes mismatched them, e.g. they are in antiphase when the path difference is nλ. 'Out of phase' was often used instead of 'antiphase'. Some candidates write 'superimpose', which is not sufficient for a mark.

When both emitters are connected the following trace 2 is recorded. When the detector is moved a small distance in the direction of the arrow shown on the diagram, trace 3 is recorded.



Trace 2



Trace 3

As the detector is moved steadily, the trace keeps changing from trace 2 to trace 3 and back again.

Explain these observations.

(6)

The 2 waves are coherent, so the 2 waves superpose, when the waves meet inphase, phase difference is integer multipe of λ (λ, 2λ, 3λ ...). Then constructive superposition occurs. This is shown or Trace 2. However when the ~~dect~~ detector is moved in the direction of arrow at a point, the waves will meet antiphase and phase difference will be odd number multiple of $\lambda/2$ ($\lambda/2$, $3/2\lambda$, $5\lambda/2$ ...) Then destructive superposition takes place. This is shown on trace 3. At which ever point there is constructive superposition a pattern like shown in Trace 2 will appear, and destructive superposition, pattern like trace 3. As in destructive waves cancel out each other.

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Examiner Comments

Phase difference has been described in terms of wavelength and there is no mention of amplitude, so there are just 3 marks for coherent sources, recognising that there is a phase difference or path difference and that superposition occurs.

ResultsPlus
Examiner Tip

Be sure you know the difference between path difference and phase difference.

As the detector is moved steadily, the trace keeps changing from trace 2 to trace 3 and back again.

Explain these observations.

(6)

The wave produced at the first position has a larger displacement then the one produced by a single transmitter. Constructive interference takes place at this position as the waves meet in phase. ($n\lambda$).

The wave produced at the second position has a less displacement then the one produced by a single transmitter. Destructive interference takes place at this position as the waves meet out of phase ($\frac{1}{2}\lambda$).

ResultsPlus

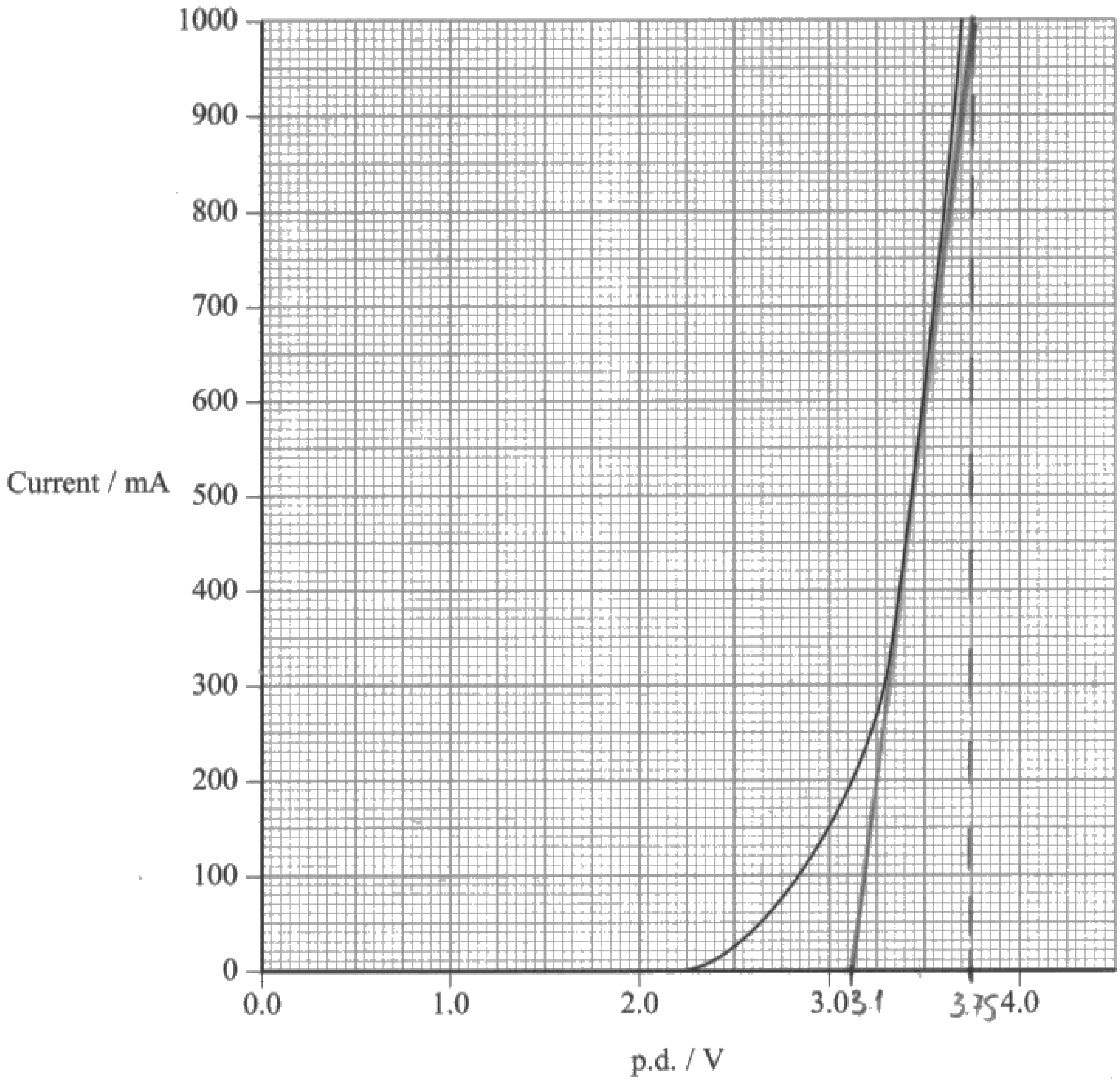
Examiner Comments

3 marks also. Here, the path difference has been given in brackets after reference to the phase relationship. This isn't explicitly called phase difference or path difference, so it doesn't contradict the earlier statement but it doesn't get a mark either. 'Out of phase' would not be sufficient to get a mark requiring 'antiphase'.

Question 15 (a)

A large majority got full marks for this calculation. Some lost a mark by inaccurately reading from the graph. A minority used the gradient as some think that the gradient of any V-I graph is equal to resistance, often after learning about fixed resistors from V-I graphs.

15 The 2014 Nobel Prize in Physics was awarded for the development of a light-emitting diode (LED) that emits blue light.
The graph shows how current varies with potential difference (p.d.) for a blue LED.



(a) Determine the resistance of the LED when the p.d. across it is 3.5 V. **(2)**

$R = \frac{1}{\text{gradient}} = \frac{3.75 - 3.1}{1 - 0} = 0.65\ \Omega$

Resistance = $0.65\ \Omega$

ResultsPlus
Examiner Comments

This is an example of a candidate using gradient to calculate resistance, which is incorrect. Resistance is the ratio of potential difference to current and not the rate of change of p.d. with current.

(a) Determine the resistance of the LED when the p.d. across it is 3.5 V.

(2)

Current = 600

$R = \frac{V}{I}$

$R = \frac{3.5}{600} = 5.8333 \times 10^{-3}$

Resistance = 5.8×10^{-3}

ResultsPlus
Examiner Comments

This has been calculated correctly but the unit has been omitted, so only the first mark is awarded.

ResultsPlus
Examiner Tip

Physical quantities have a magnitude and a unit and both must be included in your answers.

Question 15 (b)

A good majority scored one or more marks, those scoring one usually doing so for a general observation that resistance decreased with increasing p.d. A substantial minority, however, answered as if the line showed resistance rather than current, saying resistance started at zero and increased after 2.25 V.

Candidates were only asked to describe what happens and some went on to attempt to explain what happens.

(b) Describe what happens to the resistance of the LED as the p.d. across it increases from 0 V.

(2)

As p.d. increases the Current stays at 0 until p.d. reaches 2.25 V. Then after 2.4v a great increase in current is seen as the p.d. increases.

ResultsPlus
Examiner Comments

The question asks about the resistance, but this candidate has just described the variation of current shown on the graph.

(b) Describe what happens to the resistance of the LED as the p.d. across it increases from 0 V.

(2)

As the potential difference increases from 0V, the resistance remains extremely ~~high~~ low and therefore no current is produced. As soon as the ~~…~~ potential difference becomes greater than 2.1V, the resistance start to ~~decrease~~ increase.

ResultsPlus

Examiner Comments

While this answer is in terms of resistance and it is clearly distinguished from current, the pattern described is still that for current rather than that for resistance.

(b) Describe what happens to the resistance of the LED as the p.d. across it increases from 0 V.

(2)

As the potential difference increases, the resistence decreases. They are inversly proportional

The resistance starts off high and as p.d. increases the resistence decreases.

ResultsPlus

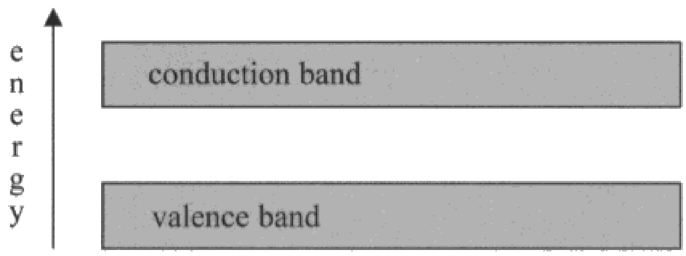
Examiner Comments

This gets a mark for the decrease of resistance over the range of the graph, but does not mention the sudden change at 2.25 V.

Question 15 (c)

Slightly under half the entry gained credit for their answers to this question, unlike similar calculations in previous sessions. Those scoring 1 often used the frequency given and the value of *h* in the data list in $E = hf$. The question clearly described the value of p.d. being measured from the graph, but this was often overlooked. Many candidates appear to see a number and rush to a calculation without spending the time on the text. Only about a third of candidates awarded 3 marks for the calculation went on to compare to *h* satisfactorily.

(c) LEDs can be used to estimate the value of the Planck constant *h*.
LEDs emit photons when electrons fall from the conduction band to the valence band.



A current is produced and light is emitted only when the p.d. is great enough to supply an electron with energy equal to the gap between the conduction band and the valence band.
The p.d. is increased from zero. The value of p.d. at which there is first a current and light is first emitted is recorded. The frequency of the light is measured at this point.

A student records the frequency of 5.7×10^{14} Hz for the LED producing the graph.
Carry out an appropriate calculation and evaluate the success of this technique at determining the value of the Planck constant.

(4)

$E = h \times f$

$h = \frac{E}{f} = \frac{E}{5.7 \times 10^{14}\,Hz}$ Plank constant $= 6.63 \times 10^{-34}$ Js

$E = h \times f$

$= (6.63 \times 10^{-34}) \times (5.7 \times 10^{14}) = 3.7791 \times 10^{-19}$ J

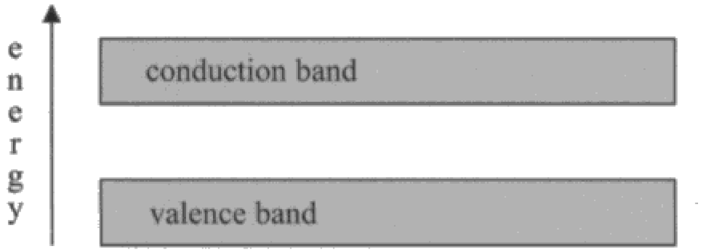
$h = \frac{3.7791 \times 10^{-19}}{5.7 \times 10^{14}} = 6.63 \times 10^{-34}$ Js

This technique is successful.

ResultsPlus
Examiner Comments

This candidate has multiplied f by h and then divided by f to get h again. A mark has been allowed for use of E = hf because candidates could use the calculated value of hf to determine the expected threshold p.d. for comparison.

(c) LEDs can be used to estimate the value of the Planck constant h.
LEDs emit photons when electrons fall from the conduction band to the valence band.



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A student records the frequency of 5.7×10^{14} Hz for the LED producing the graph. Carry out an appropriate calculation and evaluate the success of this technique at determining the value of the Planck constant.

(4)

$2.5\,eV = 2.5 \times 1.6 \times 10^{-19}\,J = 0.4 \times 10^{-18}\,J$

$0.4 \times 10^{-18}\,J = hf$

$h = \dfrac{0.4 \times 10^{-18}\,J}{5.7 \times 10^{14}\,Hz}$

$= 7.02 \times 10^{-34}\,Js$

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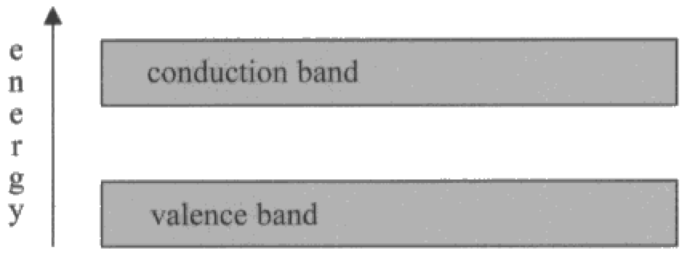
Examiner Comments

This uses the correct method, but is out of the accepted range because the graph reading was inaccurate. No evaluating comment has been made.

(c) LEDs can be used to estimate the value of the Planck constant h.
LEDs emit photons when electrons fall from the conduction band to the valence band.



A current is produced and light is emitted only when the p.d. is great enough to supply an electron with energy equal to the gap between the conduction band and the valence band.
The p.d. is increased from zero. The value of p.d. at which there is first a current and light is first emitted is recorded. The frequency of the light is measured at this point.

A student records the frequency of 5.7×10^{14} Hz for the LED producing the graph. Carry out an appropriate calculation and evaluate the success of this technique at determining the value of the Planck constant.

(4)

$E = hf$ $\quad hf = \phi - KE_{max}$

$W = V \times Q$

$= 2.5 \times 1.6 \times 10^{-19}$

$= 4 \times 10^{-19}$ J $\quad E = hf$

$\frac{4 \times 10^{-19}}{5.7 \times 10^{14}} = 7.0 \times 10^{-34}$ Js

$\frac{7 \times 10^{-34} - 6.63 \times 10^{-34}}{6.63 \times 10^{-34}} \times 100 = 5.6\%$ uncertainty

But 7×10^{-34} is very close to 6.63×10^{-34} so successful

ResultsPlus
Examiner Comments

A good calculation, still outside the accepted range, and a very good comparison with the known value of h for 3 marks.

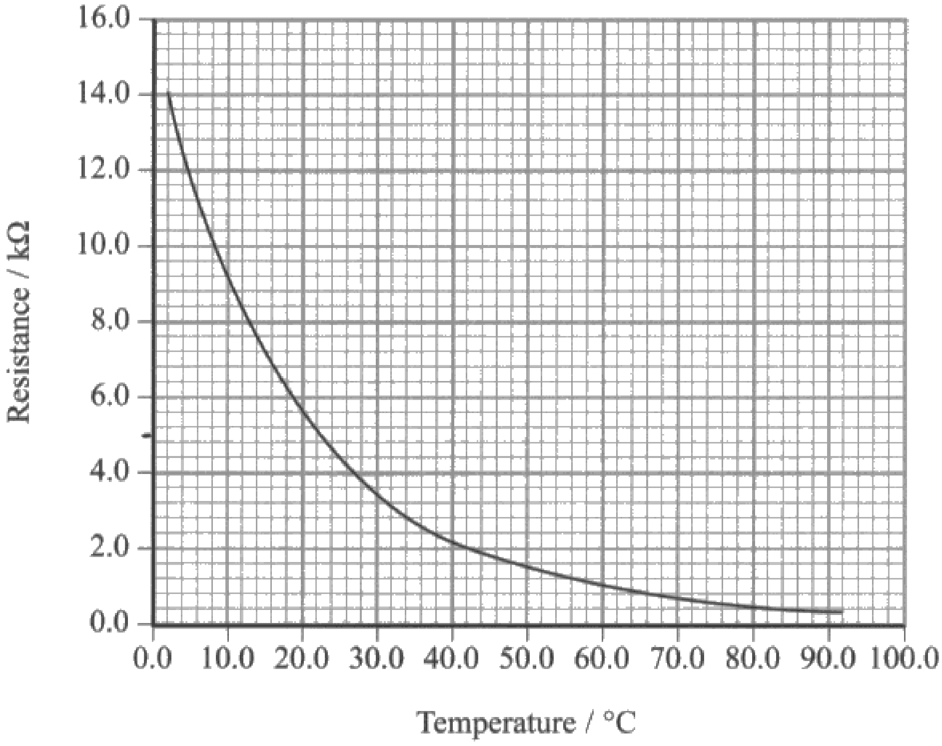
Question 16 (a) (i)

Only a minority gained any credit for this question, usually for a general statement about resistance decreasing with temperature. Many answers assumed that the line for this graph would need to be straight, either through the origin or with a negative gradient. Some interpreted the graph as showing an increase of resistance with temperature. There was little evidence of any understanding of 'inversely proportional'.

16 A student carries out an investigation to determine how the resistance of a thermistor varies with temperature.

The thermistor is placed in a beaker of water and an ohmmeter is used to measure resistance for different known temperatures of the water.

(a) The results are shown in the graph.



(i) The student states, "This graph is sufficient to show that resistance is inversely proportional to temperature".

Explain why this statement is **not** correct.

(3)

This statement is incorrect because as resistance decreases, temperature increases but the graph ~~shows~~ doesn't show a lot of variation of we can't get enough values to prove. ~~that~~

ResultsPlus
Examiner Comments

This response includes the correct general pattern for the change of resistance with temperature, although it is expresses the other way round, but does not say how the relationship should be tested.

(i) The student states, "This graph is sufficient to show that resistance is inversely proportional to temperature".

Explain why this statement is **not** correct.

(3)

To prove inverse proportionality, $R = \frac{K}{t}$

K is a constant and this relationship must be maintained ~~throught~~ all the time. In this case, the graph ~~a~~ looks like an inverse proportion, however; the values do not prove this. This only shows that when R increases, temperature decreases and vice versa

ResultsPlus

Examiner Comments

The suggested relationship has been expressed in a way that could be tested, but the details of how to test it are not included, so 2 marks are awarded.

Question 16 (a) (ii)

A majority gained some credit for this question, although only a minority scored 3 or more. Answers often went along the lines of an increase in *n* causing an increase in current, so the resistance decreased without the supporting equations or an explanation of the increase in *n*. A misconception seen quite often was that an increase in energy supplied to the thermistor increased the drift velocity of the electrons, increasing current.

(ii) Explain the graph in terms of the structure of the thermistor.

(4)

as Temperature increase the resestance decrease

↑I = ↑n Ave , so as the ~~d~~ temperature increases n increase so current increases and resestance decreases

ResultsPlus
Examiner Comments

Two marks awarded for the increase in n and using I = nAvq to identify an increase in current. There is no explanation for the increase in n and only a statement that resistance decreases.

(ii) Explain the graph in terms of the structure of the thermistor.

(4)

As the temperature increases the thermistor heats up giving the particles ~~ions~~ energy in its structure. Then more energy ~~[illegible] as they take this energy from the heat. So making it harder for charge carriers electrons to pass through as they bump into these particles losing energy therefore decreasi increasing~~ Allowing more electrons to flow freely so then allowing electricity to pass through easier as there are more free flowing electrons therefore decreasing its resistance.

ResultsPlus

Examiner Comments

Two marks again, this time for the increase in n with an explanation. It continues with the idea of an easier flow of charge, which is not sufficient.

ResultsPlus

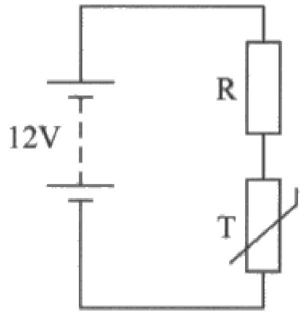
Examiner Tip

You can use equations to support your explanations.

Question 16 (b)

There were several approaches to this question and about half got 2 or more marks. The final mark was sometimes not awarded because the resistance was given as the final answer, the graph was not read accurately enough or the correct unit was not given for temperature because the C was missing.

(b) The thermistor T is placed in series with a fixed resistor R in the following circuit.



Determine the temperature for which the potential difference across the resistor R will be 8.5 V.

resistance of R = 5.2 kΩ

(3)

$V_{out} = \frac{R}{R+T} \times V_{in}$

$8.5 = \frac{5200}{5200+T} \times 12$

$5200 \div (8.5 \div 12) = 5200 + T$

$T = 7341.17 - 5200$

$T = 2141$

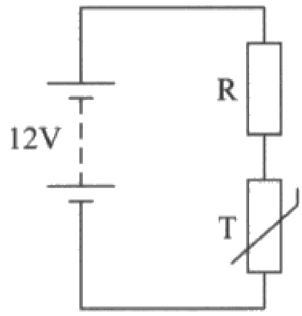
Temperature = 2141 Ω

ResultsPlus

Examiner Comments

The correct resistance has been determined using a potential divider method, but the temperature has not been obtained from the graph.

(b) The thermistor T is placed in series with a fixed resistor R in the following circuit.



Determine the temperature for which the potential difference across the resistor R will be 8.5 V.

resistance of R = 5.2 kΩ

(3)

$V = IR \quad I = \frac{V}{R} = \frac{8.5}{5.2\times10^{3}} = 1.63\times10^{-3}A$.

$12 - 8.5 = 3.5V. \quad R_T = \frac{V}{I} = \frac{3.5}{1.63\times10^{-3}} = 2.14\times10^{3}\Omega$

According to the graph, the temperature is about 40°C

Temperature = 40°C

ResultsPlus

Examiner Comments

Full marks for an alternative method involving the calculation of current.

Question 16 (c)

Over a third of the entry gained credit for answers to this question. Many candidates had some idea, but didn't explain in sufficient detail. A lot of answers just stated that there would be more chance of an error if a calculation was required. A few effectively based answers on having poor equipment, such as a voltmeter with low resistance.

(c) Explain why it is more accurate to use an ohmmeter in this investigation than a separate ammeter and voltmeter.

(2)

An ohmmeter will give both the readings, while having separate ammeter and voltmeter, it will be difficult to take two readings simultaneously.

ResultsPlus
Examiner Comments

This is a relevant point and gets one mark. It doesn't go on to explain why not taking the reading simultaneously is less accurate in terms of the resistance.

(c) Explain why it is more accurate to use an ohmmeter in this investigation than a separate ammeter and voltmeter.

(2)

Because both ammeter and voltmeter will each have a small percentage error and combine to produce a larger percentage uncertainity as $R = \frac{V}{I}$. Using an ohmmeter reduces this percentage error.

ResultsPlus
Examiner Comments

An example of a good two mark answer.

Question 17 (a)

About half of the candidates realised that the current would be very small, but very few explained the significance of this satisfactorily in terms of lost volts. They thought that current would be diverted from the battery by the voltmeter, clearly thinking of a circuit with an external resistance and the voltmeter in parallel with the battery, rather than a circuit of voltmeter and battery only.

(a) Explain why using a very high resistance voltmeter allows the e.m.f. to be measured directly.

(2)

• The high resistance ~~voltmeter~~ voltmeter does not draw any current. Therefore all current passes through the component.

• It is connected in parallel so same p.d will be across it and the component being measured so total emf.

ResultsPlus
Examiner Comments

This gets a mark for zero current, but seems to be describing a situation where the voltmeter is in parallel with a component in a series circuit. One mark awarded.

(a) Explain why using a very high resistance voltmeter allows the e.m.f. to be measured directly.

(2)

Voltage lost across the internal resistance of the cell will be very small since voltage is directly proportional to resistance and since resistance of the voltmeter is very high most of the voltage will be across it

ResultsPlus
Examiner Comments

This gets the mark for very low lost volts, but doesn't explain why.

Question 17 (b)

A large minority scored full marks for this section, and most scored at least 5, making a slip or two on the way, such as substituting into the efficiency equation 'upside-down' or using an incorrect p.d. for the power calculation.

(b) The solar cell is connected across a load resistor. The potential difference (p.d.) across the resistor and current in the resistor are measured.

p.d. = 1.60 V
current = 12.4 mA
e.m.f. = 2.04 V

(i) Calculate the internal resistance of the solar cell.

(3)

$V = \mathcal{E} - Ir$ $\quad r = 35.5\ \Omega$

$Ir = \mathcal{E} - V$

$r = \dfrac{\mathcal{E} - V}{I}$

$r = \dfrac{2.04 - 1.60}{12.4 \times 10^{-3}}$

Internal resistance = 35.5 Ω

(ii) Calculate the efficiency of the solar cell at transferring light energy to electrical energy in the load resistor.

area of cell = $1.6 \times 10^{-3}\ m^2$
radiation flux of the incident light = $270\ W\ m^{-2}$

(4)

Power ~~out.~~ input = $V \times I$

$= 1.60 \times 12.4 \times 10^{-3}$

$= 0.019\ W$

Power output = $F \times A$

$= 270 \times 1.6 \times 10^{-3}$

$= 0.43\ W$

Efficiency = useful ~~energy~~ power output / Total power input ~~× 100~~

Efficiency = 22.6

$= \dfrac{0.43}{0.019}$ ~~× 100~~

ResultsPlus
Examiner Comments

These score 3, 2. The power calculations are correct in part (ii), but input and output have been reversed in the efficiency calculation.

(b) The solar cell is connected across a load resistor. The potential difference (p.d.) across the resistor and current in the resistor are measured.

p.d. = 1.60 V
current = 12.4 mA
e.m.f. = 2.04 V

(i) Calculate the internal resistance of the solar cell.

(3)

$V_{terminal} = \varepsilon - Ir$

$1.6 = 2.04 - (12.4 \times 10^{-3})(r)$

$(12.4 \times 10^{-3})(r) = 0.44$

$r = \frac{0.44}{12.4 \times 10^{-3}} = 35.5\,\Omega$

Internal resistance = $35.5\,\Omega$

(ii) Calculate the efficiency of the solar cell at transferring light energy to electrical energy in the load resistor.

area of cell = 1.6×10^{-3} m^2
radiation flux of the incident light = 270 W m^{-2}

(4)

$I = \frac{P}{A} \Rightarrow P = I \times A = 270 \times 1.6 \times 10^{-3} = 0.432$ W

$P = IV = (12.4 \times 10^{-3})(1.60) = 0.01984$

$\%\text{efficiency} = \frac{P_{out}}{P_{in}} \times 100$

$= \frac{0.01984}{0.432} \times 100$

$= 4.59\,\%$

Efficiency = 4.59%

ResultsPlus
Examiner Comments

Typical full mark responses.

Question 17 (c)

Two thirds of students were able to apply $Q = It$, although only about a fifth of the entry gained full marks by going on to explain the situation correctly in terms of charge or energy, suggesting that they were happy with the calculation but did not understand the main concept.

(c) The battery is marked 300 mA h, 1.2 V.

A student says, "300 milliamp hours means that it stores nearly 1100 coulomb of charge." A teacher says "You have made a correct calculation, but your statement is not correct".

Explain the teacher's comment. You should include a calculation.

(3)

1 A = 1 C/s

300 mA h = 300 mA ×60 = 300 ×10^{-3} ×60 = 18 C

mAh refers to how much energy the battery can emit an hour, not how much energy it stores.

ResultsPlus

Examiner Comments

$Q = It$ has been used, but the time has not been converted to seconds. The statement about mAh referring to energy is incorrect. 1 mark

(c) The battery is marked 300 mA h, 1.2 V.

A student says, "300 milliamp hours means that it stores nearly 1100 coulomb of charge." A teacher says "You have made a correct calculation, but your statement is not correct".

Explain the teacher's comment. You should include a calculation.

(3)

Q = It => Q = (300×10^{-3})(60×60) => Q = 1080 C

The battery does not store charge.

ResultsPlus

Examiner Comments

2 marks for the correct calculation. The bare statement that the battery does not store charge is not sufficient.

(c) The battery is marked 300 mA h, 1.2 V.

A student says, "300 milliamp hours means that it stores nearly 1100 coulomb of charge." A teacher says "You have made a correct calculation, but your statement is not correct".

Explain the teacher's comment. You should include a calculation.

(3)

The student's statement is incorrect because a battery does not store charge; instead, it stores energy which it provides to the charge passing through it. ($\frac{energy}{charge}$ = potential difference) ∴ $1.2 = \frac{energy}{1080}$ and so energy = 1080×1.2 = 1296 J

• Charge = $300\times10^{-3}\times60\times60$ = 1080 coulombs ∴ This battery stores 1296 J of energy, i.e. enough to provide 1.2 volts per coulomb of charge.

ResultsPlus
Examiner Comments

This is an example of the best answers where charge and energy have both been calculated and the statement has been discussed.

Question 18 (a)

About a fifth of the entry scored for this question. Typically candidates can describe oscillations in a single plane, but in this context they didn't link it to the plane of polarisation. Having described a single plane, the usual majority of students said that the plane is perpendicular to the direction of polarisation or just described oscillations perpendicular to the direction of polarisation. A number of candidates only referred to light travelling in the plane of polarisation and did not address oscillations.

(a) Describe what is meant by the plane of polarisation of polarised light.

(2)

polarized light - particles oscillate in one plane perpendicular to direction of wave travel. plane of polarisation is the plane at which particles oscillate - change their displacement

ResultsPlus

Examiner Comments

This defines the plane of polarisation for one mark, but says the plane is perpendicular to the direction of wave travel where it should say that the plane includes the direction of wave travel .

(a) Describe what is meant by the plane of polarisation of polarised light.

(2)

The oscillations are in single plane which includes direction of energy transfer

ResultsPlus

Examiner Comments

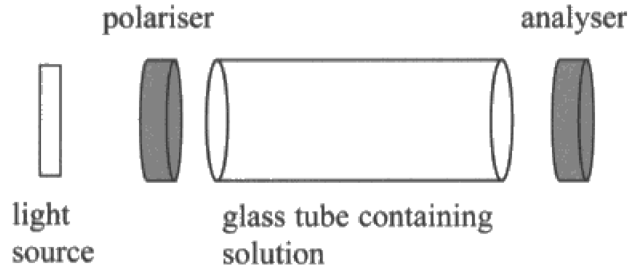
This successfully says that the plane includes the direction of energy transfer, but does not make an explicit statement about the plane of polarisation.

Question 18 (b) (i)

A majority gained at least one mark for light being absorbed or, more commonly, blocked. Half went on to explain this satisfactorily. Those that didn't generally knew that 90° was relevant, but couldn't describe exactly what was perpendicular to what, often referring to direction of travel.

(b) The diagram represents the parts of a polarimeter. The polariser and analyser are both polarising filters.

plane of polarisation can pass through the filter.



In an experiment to determine the concentration of a solution, the following steps are used.

1. The polarimeter is set up with no solution present. Light from the source is polarised by the polariser.
2. The analyser is rotated until light from the source can no longer be seen.
3. The solution is placed in the tube between the polariser and analyser.
4. The analyser is rotated until light from the source is again no longer seen.
5. The angle through which the analyser is rotated after placing the solution between the filters is measured.

(i) Explain why light from the source can no longer be seen in step 2.

(2)

→ The ~~ang~~ light ~~hits the~~ angle of incidence is greater than the critical angle of the solution

→ the angle of refraction is greater than 90°

so the light is Totally internally reflected

ResultsPlus
Examiner Comments

Candidates sometimes chose explanations unconnected to polarisation, despite words such as polariser, polarising, polarimeter and polarised appearing in the question.

(b) The diagram represents the parts of a polarimeter. The polariser and analyser are both polarising filters.

In an experiment to determine the concentration of a solution, the following steps are used.

1. The polarimeter is set up with no solution present. Light from the source is polarised by the polariser.
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3. The solution is placed in the tube between the polariser and analyser.
4. The analyser is rotated until light from the source is again no longer seen.
5. The angle through which the analyser is rotated after placing the solution between the filters is measured.

(i) Explain why light from the source can no longer be seen in step 2.

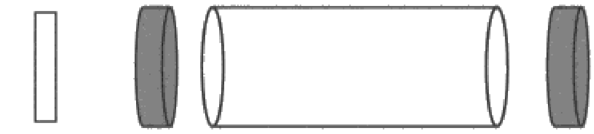
(2)

Because at that instant the light reaching the analyser has oscillations in one plane only because it has been polarised. There is no light seen when the analyser is perpendicular to the plane of polarisation of the light.

ResultsPlus
Examiner Comments

The perpendicular planes are identified, but it just repeats that no light is seen and does not refer to absorption.

(b) The diagram represents the parts of a polarimeter. The polariser and analyser are both polarising filters.



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4. The analyser is rotated until light from the source is again no longer seen.
5. The angle through which the analyser is rotated after placing the solution between the filters is measured.

(i) Explain why light from the source can no longer be seen in step 2.

(2)

The plane of polarization of light is prependicular to the plane of polarization of analyser therefore Light is absorbed

ResultsPlus
Examiner Comments

A straightforward correct answer.

Question 18 (b) (ii)

About a fifth of candidates suggested a suitable angle, but successful explanations were very rare. Students often thought that this was about further rotation of the filters. Incorrect angles included multiples of 55° and angles derived from 180° or 360° minus 55°.

(ii) When making measurements on a particular solution the angle measured in step 5 is 55°.

Explain why the plane of polarisation of the light may have been rotated by more than 55° and suggest another possible angle of rotation.

(3)

because it has passed through the ~~Stonta~~ solution. The Other possible angle could be 235° (55° + 180° = 235°).

Possible angle of rotation 235°

ResultsPlus
Examiner Comments

A correct angle has been stated, but mentioning adding 180 degrees isn't sufficient explanation for a second mark.

(ii) When making measurements on a particular solution the angle measured in step 5 is 55°.

Explain why the plane of polarisation of the light may have been rotated by more than 55° and suggest another possible angle of rotation.

(3)

Because the patern repeats each 180° degrees so than light migh have been rotated by 55° +180° = 235° because planes match every 180°.

Possible angle of rotation 235°

ResultsPlus
Examiner Comments

A correct angle has been stated along with the idea of the plane being the same every 180 degrees for two marks. The answer doesn't refer to the angle between the planes being 90 degrees again.

Question 18 (b) (iii)

About a quarter of candidates appreciated the advantage in terms of zero intensity being easier to identify, but only about a fifth of them linked this to accuracy. Other candidates just stated the need to measure the angle when the plane of polarisation of the emergent light is at 90°.

(iii) The experiment would produce the same results if the filters were arranged to give maximum intensity in step 2 and step 4.

Suggest the advantage of rotating the analyser until no light is seen.

(2)

It is difficult to determine for sure where is the maximum intensity, while to determine wether the ~~in~~ there is no light seen is much easier.

ResultsPlus
Examiner Comments

This states that it is easier to identify zero intensity, but doesn't refer to decreased uncertainty or improved accuracy.

(iii) The experiment would produce the same results if the filters were arranged to give maximum intensity in step 2 and step 4.

Suggest the advantage of rotating the analyser until no light is seen.

(2)

Detecting a maximum is harder than detecting a minimum as in a minimum the analyser must only be rotated until no light is seen while in a maximum the actual maximum intensity must be accurately determined. Thus, rotating till no light is seen leads to higher accuracy.

ResultsPlus
Examiner Comments

A typical two mark answer.

Question 18 (c)

Surprisingly for such a standard situation, half of the candidates did not gain any credit, possibly as they did not expect it as part of a question based on polarisation. As usual, some students described aspects of the photoelectric effect. Others, possibly because they saw 'monochromatic' or have used sodium lamps with diffraction gratings, discussed interference effects.

Those answering the right question did fairly well, with half getting at least half of the marks, usually for the discussion of levels and changes of levels. Candidates sometimes omitted a reference to discrete levels or didn't mention photons or link photon energy to the difference in energy between the levels. The final reference, to only specific energy changes being possible, was made infrequently.

(c) A sodium lamp is frequently used as the light source because the two bright spectral lines at 589.0 nm and 589.6 nm effectively create a monochromatic light source.

Explain how the spectral lines are created with specific wavelengths.

(6)

When a electrons absord energy , the get excited and move to higher ~~to~~ energy level ~~to~~ from lower energy level. On dexcitation, they move back to lower energy level releasing the energy ~~in~~ equal to the difference two energy states in the form of photons

$\Delta E = E_2 - E_1$

Each element has its different energy level therefore each electron has different energies absorbed in different energy level That's why different spectral lines are formed when the different energy absorbed by different electron in different energy level.

ResultsPlus
Examiner Comments

This response describes the process of excitation and photon emission for 3 marks. Discrete levels aren't mentioned and neither is E = hf. Specific energy level changes aren't mentioned.

(c) A sodium lamp is frequently used as the light source because the two bright spectral lines at 589.0 nm and 589.6 nm effectively create a monochromatic light source.

Explain how the spectral lines are created with specific wavelengths.

(6)

When ~~the~~ ~~sodiu~~ electrons exited they absorb ~~electrons~~ Energy, and when they de-exit they release energy in form of (light) photons which has a energy E = hf which is equal to the difference ~~and~~ between the energy levels in the sodium atom. And these energy levels are ~~unqiue~~ discrite so the spectral lines created ~~o~~ have a specific wavelength. Because the light given out has a specific frequency.

ResultsPlus

Examiner Comments

A relatively concise answer that is awarded 5 marks. The only part missing is the reference to only specific energy level changes being possible.

Paper Summary

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

- Learn definitions in detail so they can be quoted fully, using the required terminology.
- Know the difference between path difference and phase difference and learn the relationship between them.
- Check that quantitative answers represent sensible values and to go back over calculations when they do not.
- Learn standard descriptions of physical processes, such as spectrum formation, the Doppler effect and interference, and be able apply them to specific situations, identifying the parts of the general explanation required to answer the particular question.
- Be sure to know the standard SI prefixes.
- Be sure you know the command words and understand the level of required response for each of them, e.g. explain would mean a candidate must say why something happens and not just describe what happens.
- Explanations can often be supported by reference to formulae on the data, formulae and relationships sheet.
- When reading from graphs, look at the scale values either side of the point of interest to be sure to interpret the scale correctly.
- Physical quantities have a magnitude and a unit and both must be given in answers to numerical questions.

Grade Boundaries

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

http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx