ResultsPlus

edexcel

Examiners' Report
June 2014

IAL Physics WPH06 01

ALWAYS LEARNING

PEARSON

Edexcel and BTEC Qualifications

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

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

ResultsPlus

Giving you insight to inform next steps

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

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

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

Pearson: helping people progress, everywhere

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

June 2014

Publications Code IA039748

Introduction

The paper WPH06 assesses the skills associated with practical work in Physics and addresses the skills of planning, data analysis and evaluation. Set in a wide variety of contexts the questions will be more accessible to those candidates who have, themselves, carried out a range of practicals in the laboratory and who can formulate a plan which at this level will consist of several stages. There are questions concerning choice of apparatus, and the use of that apparatus, that will be immediately familiar to those with the experience of using such apparatus. The title of the paper, Experimental Physics, is the same as that for unit 6PH06 for UK centres and the mark scheme for each paper is designed to reflect the demands made on UK candidates in their coursework. In this way all candidates face the same test at A2.

The style of the paper is that there are four questions that combine to test the range of practical skills from the beginning of the experiment to the end. So the first question will usually address the selection and use of measuring instruments, the middle two questions will ask the candidate to plan an experiment and analyse some data from another; the plan is usually one mentioned in the specification but the analysis from an unfamiliar context. The final question asks the candidate to consider a practical situation that they might have seen in the laboratory and to answer questions on how such a practical might be carried out; there will normally be some data to analyse by drawing a graph.

Uncertainty in measurement and its effect on a conclusion are ideas that run through the paper and can occur in a variety of ways; numerical work is expected to show an awareness of the role of significant figures and physical units and candidates are expected to be familiar with standard practice in an A level physics laboratory. The specification contains examples of the subjects and techniques likely to feature in future papers and the best preparation is to carry out those experiments in the laboratory, even if only by demonstration.

Question 1

Question 1 was worth a total of seven marks; the first two were choice and use of a device to measure the diameter of a wire and the remaining five were for analysing data from measurements taken to determine the resistivity of the metal material of the wire.

Many candidates scored 6, sometimes 7 marks here.

This question is shown as one clip so that it becomes clear how one topic can provide a context for a variety of questions. Generally short answers are needed for this type of question.

1 (a) A student measures the diameter d of a thin resistance wire.

(i) State why a micrometer screw gauge is the most appropriate instrument to use to measure the diameter of the wire.

(1)

The precision of the instruement is 0.01 m and values can obtained for 3 significiant figures.

(ii) State **one** technique the student should use to determine a value for the diameter of the wire, which is as accurate as possible.

(1)

The value of diameter should taken at different places on the wire.

(b) The student also measures the length l and the resistance R of the wire. She records the following mean values.

l/cm	89.4
d/mm	0.204 ± 0.003
R/Ω	15.68 ± 0.07

(i) Use these values to calculate the resistivity of the material of the wire in Ω m.

(2)

$R = \rho l / A$

$15.68\,\Omega = \dfrac{\rho \times 0.894\,\text{m}}{3.268 \times 10^{-8}\,\text{m}^2}$

$A = \pi r^2 = \pi \times \left(\dfrac{2.04 \times 10^{-4}}{2}\right)^2 = 3.268 \times 10^{-8}\,\text{m}^2$

Resistivity = 5.73×10^{-7} Ω m

(ii) Calculate the percentage uncertainty in your value for the resistivity. You may assume the uncertainty in the value for l is negligible.

(3)

$\%\rho = \%R + \%l + \%A$

$= \dfrac{0.07}{15.68} \times 100 + \left\{ 2 \times \dfrac{0.003}{0.204} \times 100 \right.$

$= 0.446 + 2.941 = 3.4\%$

Percentage uncertainty = 3.4%

ResultsPlus

Examiner Comments

In part (a)(i) candidates were expected to mention both the precision - 0.01 mm - and the fact that this led to a small percentage uncertainty. Many candidates omitted the precision or the word 'percentage' both of which are necessary to explain why the micrometer is the most appropriate instrument. Most of the candidates scoring 6 marks overall lost this mark. In (ii) most candidates chose one of the usual techniques - as shown in the mark scheme - and a large minority mentioned zero error, this question scored very well.

Part (b)(i) required candidates to carry out the calculation and express their answer to 3 significant figures (SF) with an appropriate unit. A large number of candidates were able to do this for both marks but some found difficulty in getting the area correct. Since the data in the question is to 3 and 4 SF the answer should be expressed to the lower 3 SF.

In (b)(ii) the marks were for processing the uncertainties by doubling the percentage uncertainty for the diameter. The percentage uncertainty for the radius is the same as that for the diameter and so it is doubled when the quantity is squared. Some candidates used 0.003 as the uncertainty in the radius but a good number scored all three marks here.

ResultsPlus

Examiner Tip

Always show all your calcuations.

It is best if you show where the numbers come from by writing an algebraic equation into which you insert your numerical values. You can write the uncertainty in *d* as D*d.*

This candidate came close but a couple of crucial omissions cost them two marks.

1 (a) A student measures the diameter d of a thin resistance wire.

(i) State why a micrometer screw gauge is the most appropriate instrument to use to measure the diameter of the wire.

(1)

It has a precision of 0.001mm which allows for 4s.f, that will also give a very small uncertainty

(ii) State **one** technique the student should use to determine a value for the diameter of the wire, which is as accurate as possible.

(1)

Measure the diameter at several points from different angles and obtain an average value

(b) The student also measures the length l and the resistance R of the wire. She records the following mean values.

l/cm	89.4
d/mm	0.204 ± 0.003
R/Ω	15.68 ± 0.07

(i) Use these values to calculate the resistivity of the material of the wire in Ω m.

(2)

$R = \frac{\rho l}{A} \rightarrow \rho = \frac{RA}{l} \rightarrow \rho = \frac{15.68 \times \pi \left(\frac{0.204}{2}\right)^2}{89.4}$

$\rho = 5.73 \times 10^{-3}$ (3s.f)

Resistivity = 5.73×10^{-3} Ω m

ResultsPlus
Examiner Comments

In a)(i) it is the percentage uncertainty that must be small to improve the measurement and the key word 'percentage' is missing here.

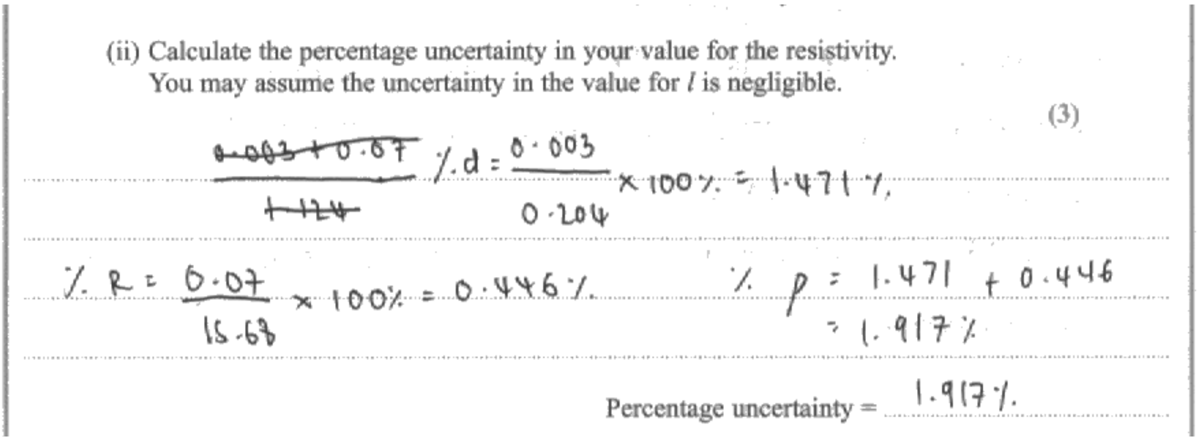
This is a good answer for a)(ii) but a surprising number of candidates omitted to take an average or mean, this is the key aspect of repeating readings.

This answer to b)(i) is laid out in an ideal way - the relevant equation is quoted and rearranged, then the numbers are substituted. But they have not paid any attention to the units and the diameter is in mm and the length in cm. It is best if these values are written down separately in Standard Form using SI units - here metres - before substituting.

ResultsPlus
Examiner Tip

Take care of the powers of ten by quoting all your numbers in Standard Form.

This is an example of how to find the overall uncertainty in a calculates quantity by combining percentage uncertainties.



(ii) Calculate the percentage uncertainty in your value for the resistivity.
You may assume the uncertainty in the value for l is negligible.

(3)

~~$\frac{0.003 + 0.07}{1.124}$~~ $\% d = \frac{0.003}{0.204} \times 100\% = 1.471\%$

$\% R = \frac{0.07}{15.68} \times 100\% = 0.446\%$

$\% \rho = 1.471 + 0.446 = 1.917\%$

Percentage uncertainty = 1.917%

ResultsPlus

Examiner Comments

The percentage uncertainties are correctly calculated by using values from the table but the diameter was squared in calculating the area so the percentage uncertainty should be doubled in this calculation.

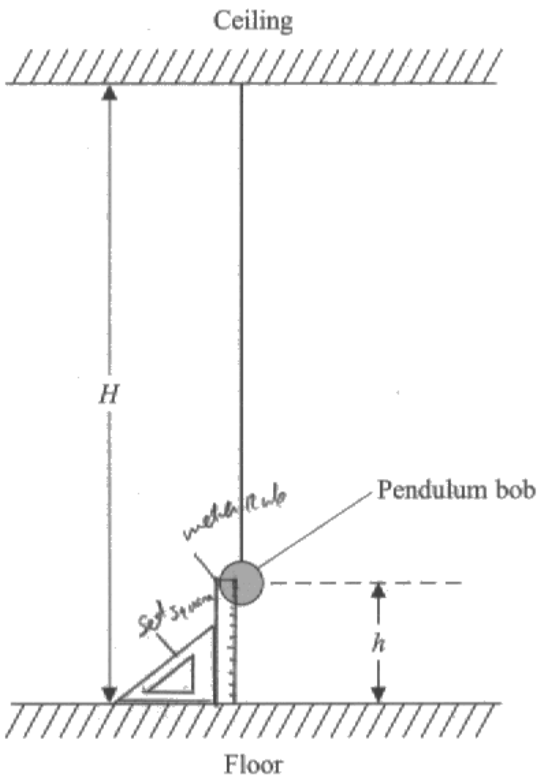
This candidate scores one mark for getting the percentage uncertainties right.

Question 2 (a)

This question addresses the technique of measuring something indirectly by using a difference method. Many candidates thought that the centre of the bob was clearly marked and some used the dotted dimension line as if it was real.

Nearly all candidates used a set square to ensure that the rule was vertical (perpendicular to the floor). This scored the first mark only, very few candidates scored more than this.

2 A student has been asked to determine the height H of a ceiling, using a simple pendulum as shown below.



The student measures the distance h from the floor to the centre of the pendulum bob. He determines values of the time period T of the pendulum for different values of h.

(a) Describe how he should use a metre rule to measure h.

You may add to the diagram if you wish.

(3)

With the use of a set square make sure the metre rule is perpendicular to the ground. Measure the distance from the top of the bob and below the bob and find the mean for the ~~se~~ centre of the bob. repeat these readings and obtain the distance h from the ground once the mean is derived.

ResultsPlus
Examiner Comments

The difference method is described clearly by this candidate and it requires the student to measure the distance of the top of the ball from the floor and also the distance of the bottom of the ball from the floor. The height of the centre of the ball is then the average of these two heights - it is also equal to half the difference added to the smaller. This answer scores the second mark.

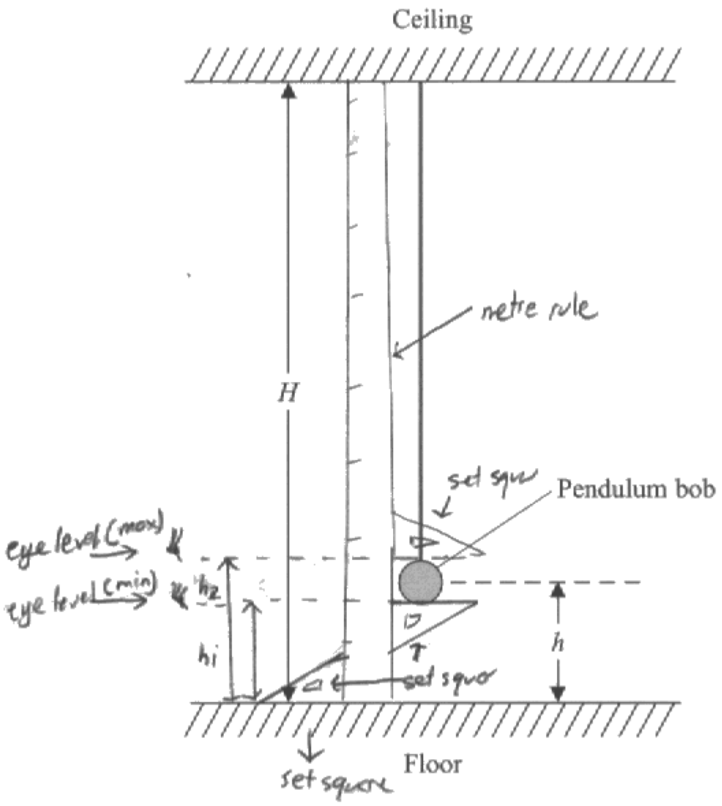
The third mark is for describing how the student can measure these heights successfully as it is not possible to look horizontally across the top/bottom of the bob at the distant rule. A second set square held alongside the vertical rule will be horizontal and it can be slid down the rule until it touches the top of the bob, the reading is then taken from where the set square touches the rule. The underside can be approached from beneath.

ResultsPlus
Examiner Tip

Adding to the diagram is a really good way to communicate with the examiner what you have in mind. It saves a lot of words.

This is a good example of a diagram reducing the amount of explanation needed.

2 A student has been asked to determine the height H of a ceiling, using a simple pendulum as shown below.



The student measures the distance h from the floor to the centre of the pendulum bob. He determines values of the time period T of the pendulum for different values of h.

(a) Describe how he should use a metre rule to measure h.

You may add to the diagram if you wish.

(3)

Ensure the ~~reading of h is~~ metre rule is perpendicular to the pendulum bob using the set square. Obtain the value of h_1 at the bottom of the pendulum bob. Obtain the value of h_2 at the top of the pendulum bob. Use a set square to ensure measurement is accurate. Obtain $h = \frac{h_1 + h_2}{2}$.

ResultsPlus
Examiner Comments

Not only is the method of using two set squares very clearly shown but the heights to be measured are clearly shown with dimension lines. The difference method appears as an algebraic expression in the text, this is all that is needed.

Question 2 (b)

Many candidates scored two marks here by measuring the time for at least ten oscillations and then repeating the measurement for a mean value.

Few candidates scored the third mark which was for technique. A timing (Fiducial) marker in the centre of the oscillation is a good technique but the oscillations will not show simple harmonic motion if the angle of swing is not small, so a small angle of swing is worth the technique mark. It is interesting to note how often candidates omit crucial aspects of the theory in discussing practical work.

This candidate scores one mark only.

(b) Describe what the student should do to make his values for T as accurate as possible.

(3)

~~Ef~~ The student should measure T for a number of times for a specific height and divide ~~by~~ the T ~~he~~ he/she found to find T for pendulum. He/she should repeat that for and find an ~~different~~ average. Then he/she should do the same for different heights

ResultsPlus
Examiner Comments

The candidate specifies 'a number of times' without saying exactly how many, at A2 we require more detail and a suitable number is 10. this makes the measured time interval large thus reducing the effect of the uncertainty in judging complete swings.

ResultsPlus
Examiner Tip

The marks is scored for repeating and finding an average for a number of measurements.

This candidate also scores the same mark but only with the benefit of doubt since they have not said what experiment they will repeat, but there is little doubt in this case. What is of interest here is the other remarks made by the candidate.

$T = 2\pi\sqrt{\frac{l}{g}}$

(b) Describe what the student should do to make his values for T as accurate as possible.

(3)

- To make T as accurate as possible the Student can repeat the experiment and by this you get the average mean to reduce error.
- The use of a light gate sensor and data logger can be useful as it records data without the factor of human error
- Carry the experiment out in a ~~room~~ closed room to avoid drafts of air from distorting the swinging of the pendulum.

ResultsPlus

Examiner Comments

In seeking to improve accuracy the candidate suggests using a light gate. This is unlikley to be successful in an oscillations experiment unless there is some way of counting more than one interruption of the light and the measurement is further complicated by the thickness of the bob. Generally moving air currents are not considered significant sources of error.

Question 2 (c)

This question tested the candidates' ability to apply their knowledge of plotting a straight line graph to an unfamiliar looking equation. As they were asked to show how the answer was derived this should have been a fairly straightforward task.

Nearly all candidates had the correct expression for the gradient but became confused about the minus sign - which should be there.

Plotting T^2 against h gives a straight line graph. $T^2 = 4H$ $\quad T^2 = 4\pi^2 H$

(i) State an expression for the gradient of the graph of T^2 against h.

(1)

~~$-4\pi^2$~~ $\quad \frac{4\pi^2}{g}$

(ii) Show that a value for H can be obtained from the expression

$$H = \frac{\text{intercept}}{\text{gradient}}$$

(2)

$T^2 = \frac{4\pi^2 H - 4\pi^2 h}{g}$ $\quad T^2 g = 4\pi^2 H - 4\pi^2 h$

$\frac{T^2 g + 4\pi^2 h}{4\pi^2} = H$ $\quad \frac{T^2 g}{4\pi^2} + h = H$

Since gradient $= \frac{4\pi^2}{g}$

$\frac{4\pi^2 H}{g} = $ intercept

ResultsPlus

Examiner Comments

In part (ii) here the candidate persists in using T^2 which is confusing. Many candidates did not use the fact that the intercept was the value of T^2 when h was zero which led to some tricky algebra - as here. However they did score the first mark by identifying the intercept clearly.

This candidate starts from the answer and works back. This is a technique that might not score all the marks on some questions but it does so here.

(ii) Show that a value for H can be obtained from the expression

$$H = \frac{\text{intercept}}{\text{gradient}}$$

(2)

y-intercept $= \frac{4\pi^2 H}{g}$, gradient $= \frac{4\pi^2}{g}$.

$$\frac{\text{intercept}}{\text{gradient}} = \frac{\frac{4\pi^2 H}{g}}{\frac{4\pi^2}{g}} = H$$ as shown.

ResultsPlus

Examiner Comments

The candidate identifies both the terms and then divides them to arrive at H as required.

ResultsPlus

Examiner Tip

Use what you know - even just writing it down can help you see through to an answer.

This is a much neater solution.

$$\frac{4\pi^2 H}{g} = \text{y-intercept} \quad ; \quad H = \frac{\text{y-intercept} \cdot g}{4\pi^2}$$

$$\frac{g}{4\pi^2} = \frac{1}{\text{gradient}} \quad ; \quad H = \text{y-intercept} \cdot \frac{1}{\text{gradient}}$$

$$\boxed{H = \frac{\text{y-intercept}}{\text{gradient}}}$$

ResultsPlus
Examiner Comments

The candidate starts with the intercept and moves through the work keeping *H* in view all along.

Question 3

This question asked candidates to use some data from an experiment that should be familiar to them, they are to use the data to draw a conclusion about the eventual determination of Planck's constant. This involves calculating uncertainties and using them to compare two values.

This question spread out the candidates and the mean mark was just over 5 so many performed well here.

This is a candidate who scored full marks, the work is laid out neatly and appropriate use is made of Significant Figures and units.

By measuring the diameter of the rings it is possible to calculate a value for the wavelength λ of the electrons from

$$V = k\lambda^{-2}$$

where k is a constant.

The following data were recorded for two different values of V.

$\frac{V}{m^{-2}}$

V/kV	$\lambda/10^{-12}$ m	λ^{-2} / $\times 10^{23}$ m^{-2}
200	2.51	1.59
300	1.95	2.63

(a) (i) Calculate a value for k. You may add to the table if you wish.

(3)

$1000 \times 200 = k(1.59 \times 10^{23}) \Rightarrow k = 1.26 \times 10^{-18}$

$1000 \times 300 = k(2.63 \times 10^{23}) \Rightarrow k = 1.14 \times 10^{-18}$

$\therefore$ Mean = $k = 1.20 \times 10^{-18}$ Vm^2

k = ...

(ii) Estimate the percentage uncertainty in your value for k.

(1)

$\frac{1}{2}$ range = 0.06×10^{-18} $\Rightarrow$ %U = $\frac{0.06 \times 10^{-18}}{1.20 \times 10^{-18}}$ = 5%

Percentage uncertainty = ...

(b) Theory suggests that

$$k = \frac{h^2}{2em_e}$$

where h is the Planck constant, e is the electron charge and m_e is the electron mass.

(i) Use your value for k to calculate a value for h.

(2)

$1.20 \times 10^{-18} = \frac{h^2}{2(1.6 \times 10^{-19})(9.11 \times 10^{-31})}$ ⇒ $h^2 = 3.50 \times 10^{-67}$ ∴ $h = 5.91 \times 10^{-34}$

$h =$ 5.91×10^{-34} Js

(ii) Estimate the percentage uncertainty in your value for h.

(1)

% u for k = 5% ⇒ for h^2 ⇒ % u = 5%

∴ for h ⇒ % u = 2.5%

Percentage uncertainty =

(iii) Comment on the validity of your answer for h.

(2)

% Difference from correct h value

$= \frac{6.63 \times 10^{-34} - 5.91 \times 10^{-34}}{6.63 \times 10^{-34}} \times 100 = 10.9\%$

Since % Difference > % Uncertainty, not a valid answer for h.

Experimental uncertainty doesn't account for difference from correct value

ResultsPlus

Examiner Comments

Many candidates scored well but the most common errors were as follows.
Most common was to omit the unit in (a)(i) and in b(i).

Since 200 and 300 could be to 1, 2 or 3 SF candidates should use 3 SF as shown by the wavelength values.

Some candidates did not realise that the table contained two readings at different settings and tried to find the means for voltage and wavelength.

In (b)(ii) the uncertainty in *h* is half that in (a)(ii) since it is from the calculation in (b)(i).

(b)(iii) was generally done well with candidates making good comments based on the percentage difference calculation and its comparison with the percentage uncertainty - as here.

ResultsPlus

Examiner Tip

Read the question carefully and read the final instruction twice.

Question 4 (a)

There are always some marks for simple knowledge of physics (Assessment Objective 1) and these were two such marks here.

An A level physics candidate is expected to be able to explain the reason for the decrease in resistance in terms of the increased number of charge cariers, a fair number did this but very few made the link to the thermal energy that promoted/liberated these electrons enabling them to move through the material and increase conductivity. A common error was to suggest that the thermal energy increased their kinetic energy so increasing their drift velocity - this scored zero.

This answer scores the first mark, but not the second. A question asking for an explanation always has at least 2 marks one for identifying the key factor - here the increase in the number of charge carriers - and on for explaining the reason - here, the electrons acquire some of the thermal energy arriving which enables them to rise up to the conduction band.

4 (a) Explain why the resistance of a thermistor decreases as its temperature increases.

(2)

$V = IR$ $\quad$ $I = nAvq$ $\quad$ As temperature increases more charge carriers are

$V/R = I$ $\quad$ released so then more current can flow through it

and the resistance decreases.

ResultsPlus
Examiner Comments

This candidate includes the drift velocity equation but without referring to it, so it is worthless in the answer.

Many candidates thought the thermal energy increased the kinetic energy of the electrons and made them travel faster. In fact the drift velocity reduces but the effect of this - which is what happens in a metal - is swamped by the exponential increase in the number of charge carriers caused by the thermal energy.

ResultsPlus
Examiner Tip

'Explain' means that you should use some physics in your answer.

4 (a) Explain why the resistance of a thermistor decreases as its temperature increases.

(2)

As temperature increases, ~~no~~ number of charge carriers increases due to more energy hence more current flows decreasing the resistance of the thermistor.

ResultsPlus

Examiner Comments

Although the link to energy is weak it is clearly the reason for the increase in number of charge carriers.

Question 4 (b)

This question tests the candidates' knowledge and understanding of an experiment involving a change of temperature as the independent variable. Any suitable method is accepted but the candidate must make it clear exactly what they are planning and how it will happen. Bullet points rather than sentences are an ideal way to lay out the steps in a plan, this makes it easier for the candidate to check that the plan includes everything and is in a sensible order.

Some candidates used a water bath, or perhaps a series of them, to change the temperature of the thermistor, but in any set up the pause to allow for thermal equilibrium to be established is vital in obtaining accurate results.

This candidate's diagram is large, this is a good thing, and it includes the electric circuit as well as the bench arrangement. It is not necessary to include the electric circuit components in the bench diagram, only the thermistor. If the apparatus is labelled in the diagram it is not necessary to write a list in the text part of the answer.

A good diagram sets up a good answer that is likely to score all the marks - make it large and clear.

(b) Plan an experiment to determine how the resistance of a thermistor changes as its temperature is increased from 0 °C to 100 °C.

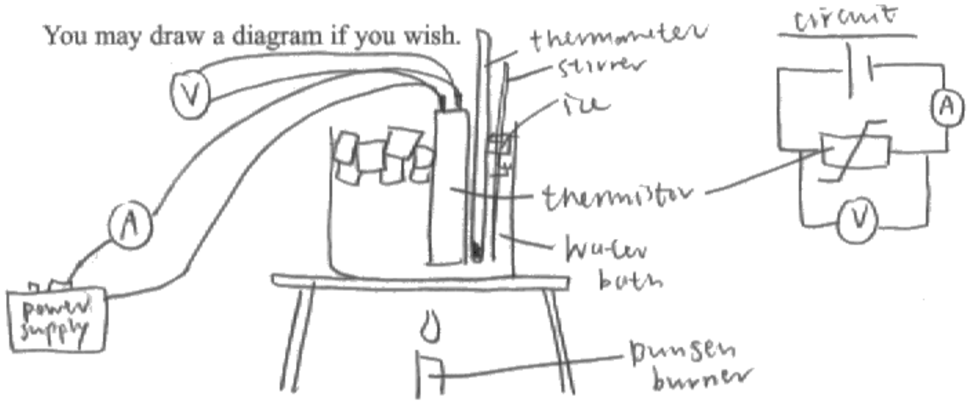
Your plan should include:

(i) the apparatus required, **(2)**

(ii) how you would obtain the temperature range, **(1)**

(iii) the precautions you would take to ensure accurate measurements. **(2)**

You may draw a diagram if you wish.



(b)(i) apparatus required including a power supply, a voltmeter, an ammeter, a thermometer, some connecting wires, a waterbath, a Bunsen burner ~~and~~ some ice ~~and~~ a thermistor and a stirrer.

(ii) Add ice to the waterbath and stir and read thermometer to check and achieve 0°C. Turn on the ~~the~~ bunsen burner and heat the water and temperature will reach 100°C when water in the water bath boils.

(iii) Remove the heat source and take readings after a minute to allow time for the water and the thermistor to come to thermal equilibrium so temperature readings taken is the temperature of the thermistor. ~~heat source to~~ Also, remove the heat source to ensure temperature are steady when taking readings. The thermometer must be close to ~~heat~~ thermistor and should touch the bottom and the side of the beaker. Always stir the water in the water bath

ResultsPlus
Examiner Comments

Most candidates scored both of the first two marks in (i).

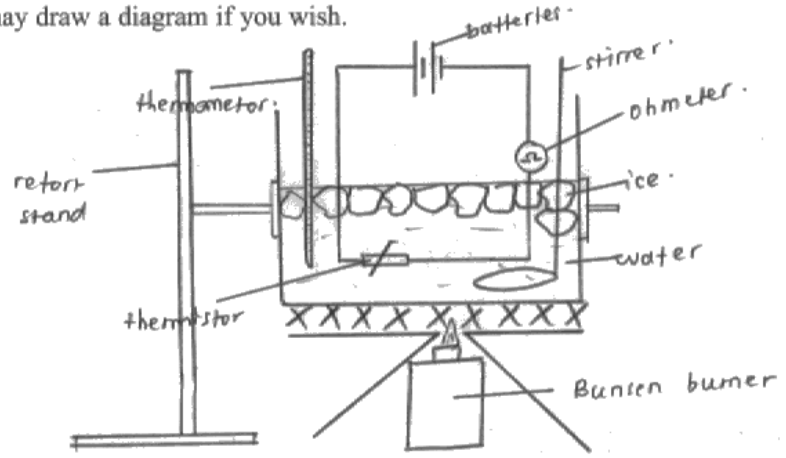
Some candidates did not take the hint from the question that the freezing and boiling points of water were required. So the answer for (ii) needed a mention of ice and heating from a source for the mark.

The precautions were usually explained well and this answer includes most of them even though only two were necessary - for the two marks available. A few candidates wrote about safety precautions rather than precautions designed to produce an accurate value.

ResultsPlus
Examiner Tip

Draw a clearly labelled and large diagram.

You may draw a diagram if you wish.



(b).

ResultsPlus
Examiner Comments

The thermometer is shown quite close to the thermistor but the electric circuit is wrong, the ohmmeter does not require an external power supply. There are enough other features to score both the marks - it is a good idea to label the heat source.

Question 4 (c) (i)

This part asks the candidates to show how the data might be plotted to give a straight line. As is usual in this part of the question the logarthim expansion of the equation should be written down and compared with the equation for a straight line graph - usually written as *y =mx + c.*

(i) Show that a graph of $\ln R$ against θ should be a straight line.

(1)

$\ln R = -\alpha\theta + \ln R$

ResultsPlus
Examiner Comments

This candidate scores zero because there is no indication how this will be a straight line. The simplest way to say this is by saying that the gradient will be equal to -α.

(i) Show that a graph of $\ln R$ against θ should be a straight line.

(1)

$\ln R = \ln R_0 - \alpha\theta$ which is similar to $y = mx + c$ with $-\alpha$ as the gradient.

ResultsPlus
Examiner Comments

This is the ideal answer. The only way it could be clearer would be if the equation was written *y* = *c* - *mx* thus mirroring exactly the logarthmic expansion above.

Question 4 (c) (ii-iii)

This question is one where most candidates could probably score better. There are usually four marks for plotting graphs they are for data table values, axes, labels, scales, plots and line of best fit (lobf); they are usually grouped into data, axes & labels, scales, plots and lobf - sometimes scales and plots go together with the fourth mark for the lobf, but not this year.

The mark for the data values is for obtaining the correct values (powers or logarithms) to an appropriate number of figures. The appropriate number is judged by what can be used on the graph paper and for logarithmic axes this is usually 3 decimal places since we aim to plot to the nearest millimeter or half a small square.

The axes must be as in the question unless there is no instruction so here we expect ln *R* on the vertical axis and θ on the horizontal one. The label should be written as quantity/unit but for a logarithmic axis, as here, we accept only ln (R/Ω), that is log or ln(quantity/unit).

Scales should spread the plotted points over at least half of the grid along both axes and plots should be accurate to 1/2 of one small square or one millimeter. The lobf should have some plots above it and some below and should not be forced through a point such as the origin.

The gradient of the line is measured using a large triangle, as large as possible is best. Measurements should be accurate to the nearest millimeter and if the gradient is being used to find a value for a quantity - as here, it is α - then it might well have units. Gradients and subsequesntly derived values should have 3 significant figures as that is what is expected in all aspects of graphical work.

This year the question used the temperature coefficient of resistance of a thermistor as the context and candidates scored about the same as they have done on previous such questions. It should be noted that candidates can use as units for resistance either Ohms or kiloOhms providing that they take the logarithm as appropriate which most candidates did. The gradien will be the same value.

In this example the candidate scored full marks for the gradient use in (iii) but only scored two marks for the graph.

(ii) In an experiment to measure R and θ the following data were recorded.

θ / °C	R / kΩ	ln(R/kΩ)
19	6.17	1.820
30	4.35	1.470
42	2.66	0.978
50	1.96	0.673
62	1.25	0.223
70	0.906	−0.099

Use the grid opposite to draw a graph of ln R against θ. Use the column in the table for your processed data.

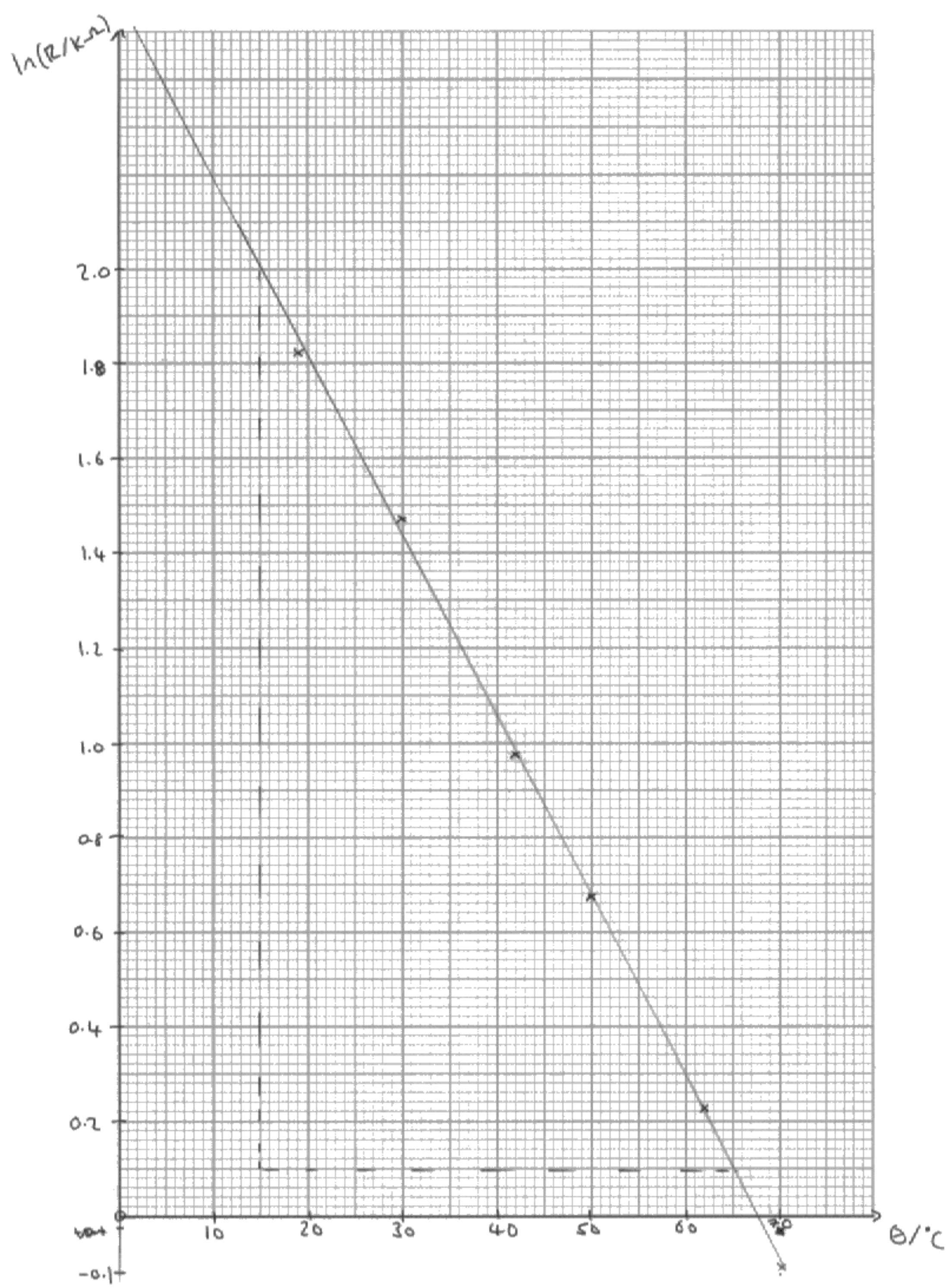
(4)

(iii) Use your graph to determine a value for α.

(3)

$\frac{2.0 - 0.1}{65 - 15} = 0.0380\ °C^{-1}$

α = 0.0380 °C^{-1}


ln(R/kΩ)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
-0.1
10
20
30
40
50
60
70
θ/°C

ResultsPlus
Examiner Comments

The data is to 3 decimal places which enables precise plotting and the labels are correct but the scale is disappointing. The scale is the best size but the whole grid should be moved up by 2 cm so that the 70°C point lies on the graph paper and not below it. This loses the scale mark and the lobf mark as it is an error of physics and as such loses two marks. In practice the graph does not use all the data which is not correct.

For the gradient the triangle is commendably large and as it happens the points chosen lie exaactly on gris lines so we can ignore the absence of trailing zeros because we would normally penalise fewer than 3 SF. The candidte neatly cancels the minus signs and arrives at a correct value for a with 3 SF and the correct unit - good work.

ResultsPlus
Examiner Tip

There is a lot to get right on this question - it pays to spend time and take care.

This graph is ideal and scores full marks.

The gradient calculation produces exactly the same calculation but scores only 2 out of 3.

(ii) In an experiment to measure R and θ the following data were recorded.

θ / °C	R / kΩ	ln (R/kΩ)
19	6.17	1.820
30	4.35	1.470
42	2.66	0.978
50	1.96	0.673
62	1.25	0.223
70	0.906	-0.0987

Use the grid opposite to draw a graph of ln$R$ against θ. Use the column in the table for your processed data.

(4)

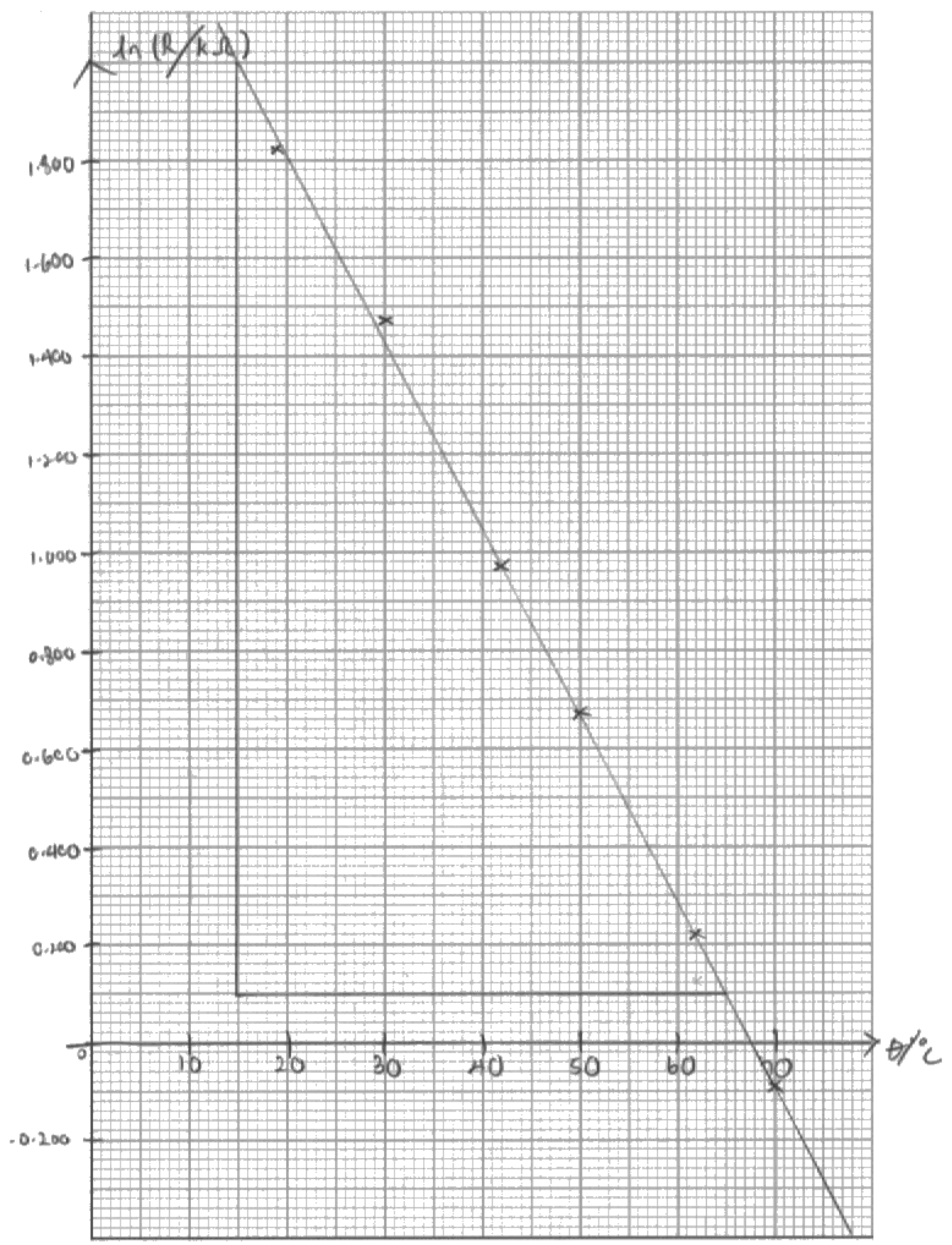
(iii) Use your graph to determine a value for α.

(3)

$\alpha = \frac{2.000 - 0.100}{15 - 65}$

$= -0.038\ °C^{-1}$

$\alpha =$ $-0.038\ °C^{-1}$



ResultsPlus
Examiner Comments

This graph is worth noting as it is clear, neat and carefully constructed.

This candidate makes exactly the same calculation but uses only 2 SF and loses the final mark even though the unit is correct. Since the precision of the thermometer is only 2 SF but the ohmmeter rather more we can reasonably expect 3 SF for the gradient - this is usually the case for graphical work. How the data might be used beyond this is a different question.

Paper Summary

This paper featured measurements of resistivity and its attendant uncertainty, an unusual treatment of a simple pendulum, measurements of the wavelength of electrons - this time using the uncertainties to reach a conclusion - and an experiment about the thermal beaviour of a thermistor. Generally the paper was done well with candidates scoring good marks and there was little evidence that candidates had had insufficient time tackle all the questions asked.

Candidates should not repeat the question as part of their answer as this uses up space that is intended for their answer, this way they would not require an additional answer sheet.

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

Pearson Education Limited. Registered company number 872828
with its registered office at Edinburgh Gate, Harlow, Essex CM20 2JE