Advanced subsidiary GCE Physics B

Unit G491 Physics in Action - High banded Candidate style answer

Introduction

OCR has produced these candidate style answers to support teachers in interpreting the assessment criteria for the new GCE specifications and to bridge the gap between new specification release and availability of exemplar candidate work.

This content has been produced by senior OCR Examiner's, with the input of Chairs of Examiner's, to illustrate how the sample assessment questions might be answered and provide some commentary on what factors contribute to an overall grading. The candidate style answers are not written in a way that is intended to replicate student work but to demonstrate what a "good" or "excellent" response might include, supported by examiner commentary and conclusions.

As these responses have not been through full moderation and do not replicate student work, they have not been graded and are instead, banded "medium" or "high" to give an indication of the level of each response.

Please note that this resource is provided for advice and guidance only and does not in any way constitute an indication of grade boundaries or endorsed answers.

1 Here is a list of electrical units

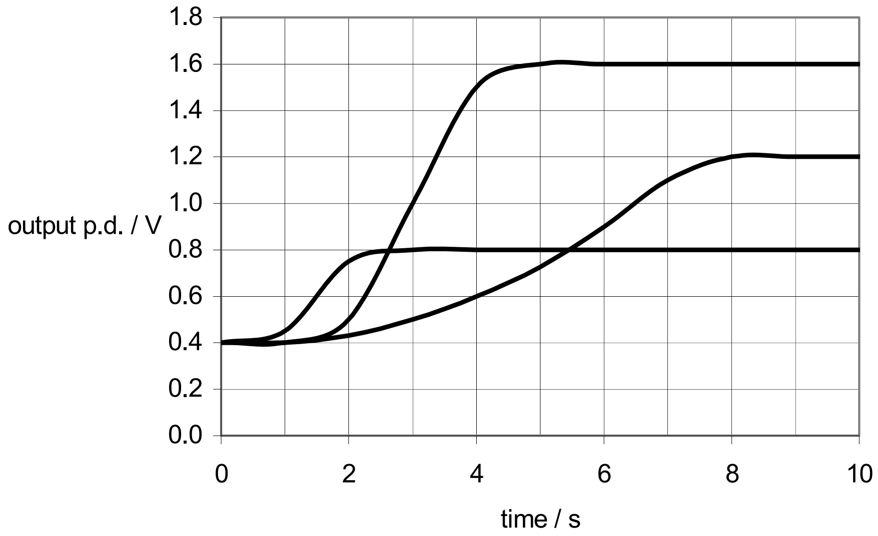
A s **C s^{-1}** **J s^{-1}** **J C^{-1}** **V A^{-1}**

Choose the correct unit for

[3]

Candidate style answer	*Examiner's commentary*
(a) electric current. *C s^{-1}* **(b) resistance.** *V A^{-1}* **(c) potential difference** . *J C^{-1}*	These are the correct answers. If you cannot remember the unit for a quantity, go back to the defining equation which shows its relationships to other quantities. So here: current = charge per time ($I = Q / t$) resistance = p.d. / current ($R = V / I$) ; p.d. = energy change per charge (V = *E / Q).* Then the unit equivalents for the Amp, Ohm and Volt should be apparent.

2 Three temperature sensors <u>A, B</u> and <u>C</u> were plunged into boiling water at the same moment. The graph below shows their responses.



(a) State the sensor with the longest response time.

[1]

Candidate style answer	Examiner's commentary
B.	Correct answer.

(b) The temperature rise of each sensor was 80 ºC.

Calculate the average sensitivity of sensor A between room and boiling water temperatures.

sensitivity = ΔV / ΔT = (1.6 – 0.4)V / 80 ºC = 1.2 / 80 = 0.015 V / ºC

[2]

Candidate style answer	Examiner's commentary
Sensitivity = 15 unit mV °C-1	Response time means the time interval from when the change of conditions starts to when the output is stabilised at its new level (or a fixed fraction of it). **B** is correctly the slowest to respond, and has the longest response time. For an electrical sensor, the sensitivity is defined as: sensitivity = change in electrical output / change in physical variable measured = $\Delta V / \Delta T$ All three sensors change temperature (ΔT) by 80 °C. **A**'s output p.d. rises from 0.40 to 1.60 Volts (ΔV = after – before = 1.60 – 0.40 = 1.20 Volts) So $\Delta V / \Delta T$ = 1.20 / 80 = 0.015 V °C^{-1}

3 Fig. 3.1 and Fig. 3.2 show two satellite images, taken about two weeks apart in early 2000, of the Ninnis Glacier disintegrating into the Antarctic Ocean.

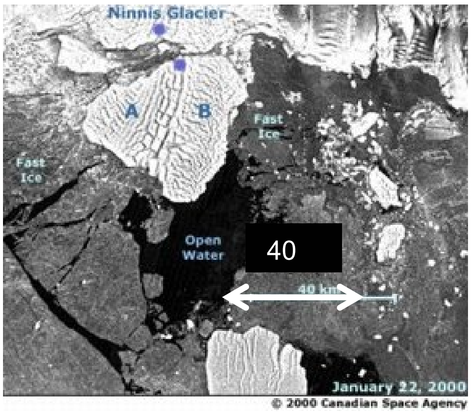


Fig. 3.1

Fig. 3.2

(a) Both images are 300 pixels wide x 250 pixels high. A 40 km scale marker has been added to Fig. 3.1.

Estimate the resolution of these images question

[1]

Candidate style answer	*Examiner's commentary*
marker width / image width = 2.9 cm / 9.0 cm = 0.322 marker covers 0.322 x 300 pixels = 97 pixels resolution = distance represented / pixel = 40 km / 97 pixels = 0.412 km pixel-1 resolution = ……410… (2 S.F.)... m pixel-1	This is a very precise answer. But the question says estimate; another student might have said that the distance marker is about ⅓ of the 300 pixel image width. So 40 km is 100 pixels, therefore 0.40 km per pixel, or 400 m per pixel. This would be within tolerance.

(b) Estimate the distance ice shelf B has drifted during the two weeks.

[1]

Candidate style answer	*Examiner's commentary*
Estimating the distance moved to be ≈ ½ length of the distance marker gives 20 km. distance = …….20 …….. km	This estimate is within tolerance. Alternatively you could measure the distance moved on the image with a ruler (about 1.6 cm) and compare it to the length of the distance marker (3.0 cm). Then the distance moved estimate is (1.6 / 3.0) x 40 km = 21 km

(c) The images show the first large-scale break up of the Ninnis Glacier in recorded history.

Suggest one way in which the evidence presented in this pair of images is important to humans.

[1]

Candidate style answer	*Examiner's commentary*

The melting of glaciers can be regarded as evidence for global warming.	This answer is rather brief; it should perhaps mention a consequence to humans such as rising sea levels and possible flooding of coastal deltas or population movements.

4 Fig. 4.1 shows two waveforms displayed on an oscilloscope screen.

One is the original analogue signal from a recording of a dolphin whistling.

The other is the result of digitising it to the nearest of 8 binary coded levels

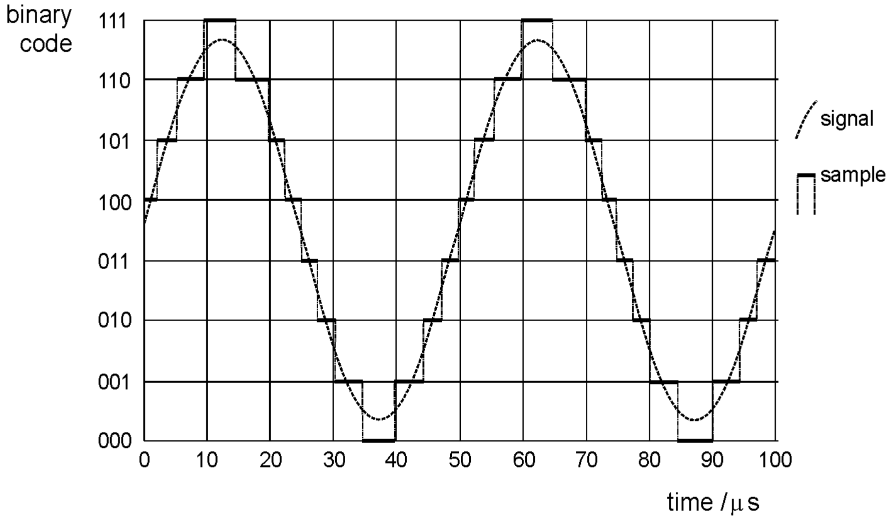


Fig. 4.1

(a) (i) Read from the graph the time period T in microseconds for one complete cycle of the dolphin whistle.

[1]

Candidate style answer	*Examiner's commentary*
T = ……...50………… μs	The candidate has correctly identified the time period from the waveform in (ai).

(ii) Calculate the frequency *f* corresponding to this time period *T*.

[1]

Candidate style answer	*Examiner's commentary*
frequency = 1 / time period = 1 / (50 x 10-3 s) = 103 / 50 f = ……..20. Hz	In (aii) a common error has been made with powers of ten, 1 μs is 10^{-6} s not 10^{-3} s (1 millisecond). So the correct answer is 20 000 Hz (20 kHz). If you can't remember the value of the prefix multipliers e.g. milli (m), micro (μ), nano (n) etc. they are available for you to check in the exam in the formulae and relationships sheet.

(b) The waveform is sampled every 1.0 μs.

Calculate the rate at which the sampled information is transmitted.

[2]

Candidate style answer	*Examiner's commentary*
information rate = bits per sample	Part (b) is well answered; the candidate makes

x samples per second = 3 x 10^6 bits per second information rate = 3 x 10^6 bits s^{-1}	the method entirely clear by using word relationships involving the units involved.

5 An original signal of amplitude 3.0 V has a random noise signal of amplitude 0.5 V added to it. **Calculate the maximum number of bits per sample that can be coded for this signal.** **[1]**	
Candidate style answer	*Examiner's commentary*
A 2 bit code gives 2^2 = 4 levels giving 3 intervals of about 2 V size each, too big. A 3 bit code gives 3^2 = 8 levels giving 7 intervals of about 1 V size each, just right for noise of amplitude 0.5 V. maximum number of bits per sample =3..	The answer is perfectly satisfactory. The noise is about 1/7 of the amplitude of the total signal (≈ 0.5 / 3.5), so there is no point in having the resolution finer than this. 7 intervals needs 8 levels of coding, since 2^3 = 8, so 3 bits is sufficient. Or bits = $\log_2 (V_{total} / V_{noise}) = \log_2 (3.5/0.5) = \log_2 (7)$ = 2.8 best rounded up to 3.

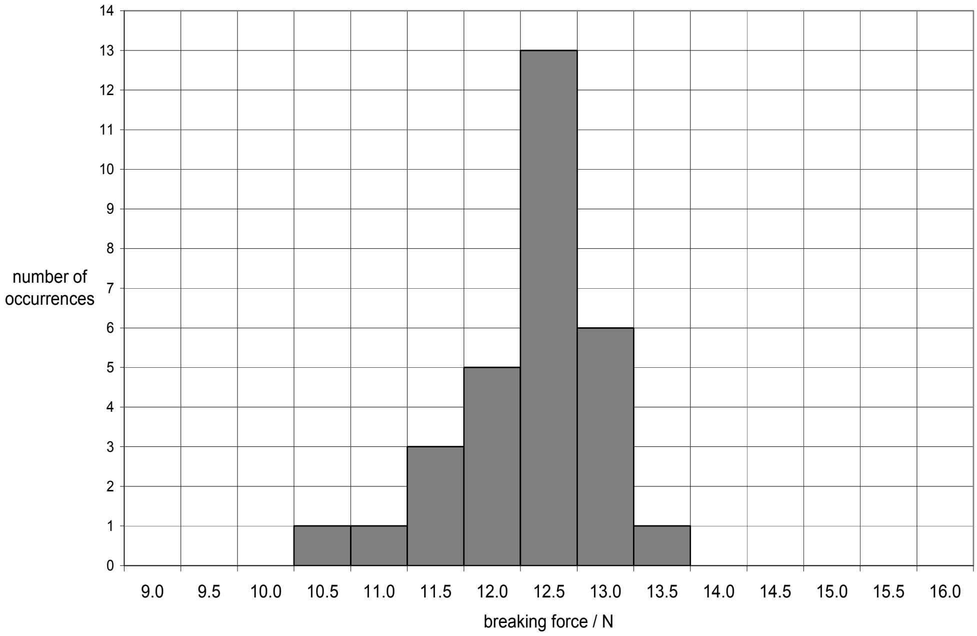
6 Here are five mechanical properties of materials **elasticity hardness toughness stiffness strength** **For each of the following descriptions of mechanical properties of materials write down the property being described from the list.** **[2]**	
Candidate style answer	*Examiner's commentary*
the stress required to break a material *strength.* **a measure of the difficulty of scratching or denting the material** *hardness.*	These are the correct answers. Remember the strength of a material is given as a stress (force / x-sectional area), because larger x-section specimens of the same material will require proportionately larger forces, but will all break at similar stresses.

7 A resistor is rated at 470 Ω and maximum power of 0.50 W. **Calculate the potential difference across the resistor, when running at its maximum power.** **[2]**	
Candidate style answer	*Examiner's commentary*
P = V2 / R so V = √ (P R) = √(0.5 x 470) = 15.3 V potential difference = ...15...(2 S.F.).V	The candidate has jumped straight to the relationship needed, between *P, V* and *R*. If this is not obvious you will need to combine the two GCSE relationships: *P = I V* and *V = I R and* eliminate the current

	I which is not required in this case. This gives power $P = (V/R) \times V = V^2 / R$ Since the data in the question is given to 2 S.F. it is best to quote the final answer to 2 S.F. also.

8 A class experiment sets out to measure the breaking force of cotton thread.

The histogram below shows the frequency of occurrence for each breaking force measured.



Showing your working clearly, state your best estimate of the breaking force of this cotton thread.

Give an estimate of the uncertainty in the measurement.

Give your answers to a sensible number of significant figures.

[3]

Section A Total: [21]

Candidate style answer	*Examiner's commentary*
mean = (1 x 10.5 + 1 x 11 + 3 x 11.5 + 5 x 12 + 13 x 12.5 + 6 x 13 +1 x 13.5) / 30 = 370 / 30 = 12.33 uncertainty = ± ½ range = ± 1.5 N breaking force = ...12.3... ± 1.5. N	The candidate's method for the mean is clear and correct. Other acceptable answers here would be to state the median value as a best estimate (middle value in rank order), in this case 12.5 N. Or the mode value, also 12.5 N. But notice that working must be shown, so here a justification would need to be given; perhaps that the distribution is reasonably symmetric with no outliers, so the mode is a reasonable estimate 3 S.F. in the final answer is sensible here, to match the original data. For S.F. in estimating the uncertainty, 1 (or 2 max) should be acceptable, so ±1 N a bit optimistic, ± 2 N a bit pessimistic, and ± 1.5 N should all be acceptable estimates.

9 A vertical filament lamp is set up a distance *u* in front of a converging lens as shown in Fig. 9.1. A real image of height *h* is focused on the screen at distance *v* from the lens.

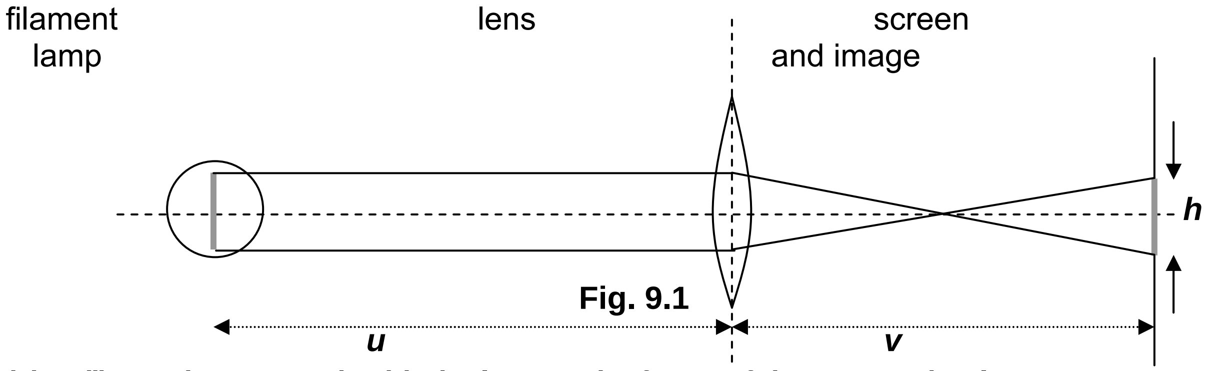
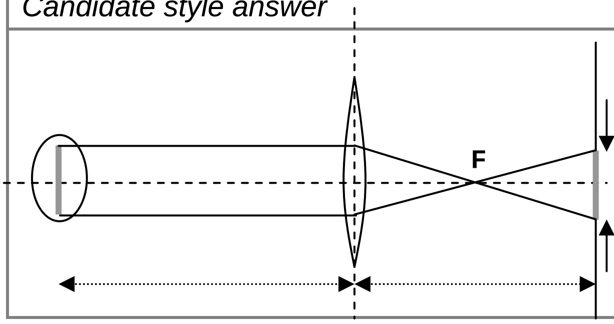


Fig. 9.1

(a) (i) On Fig. 9.1, mark with the letter F the focus of the converging lens

[1]

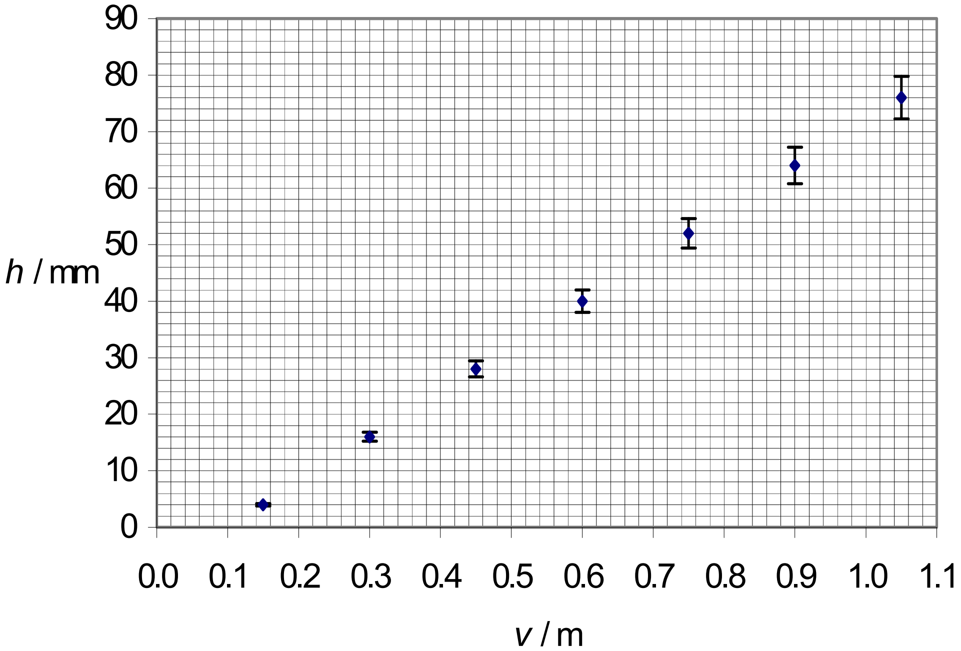
Candidate style answer	*Examiner's commentary*
	Correct answer.

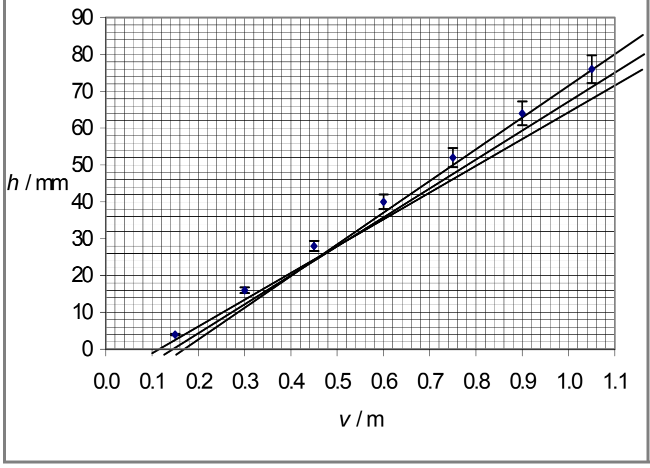
(ii) Explain using Fig. 9.1 why in this example the real image is not formed at F.

✐ You will be awarded marks for the quality of your written communication.

[2]

Candidate style answer	*Examiner's commentary*
A converging lens produces a real image of a very distant object at the focus of the lens. This is because the rays from a single point on the distant object arrive effectively parallel at the lens, and then pass through F. In the diagram the two parallel rays are from **two** points (top and bottom) of object, and although they cross at the focus, no image is formed here. As the object approaches the lens the image gets further away from the lens, which is illustrated in the diagram.	The candidate has explained the image formation well and in good technical English, so would gain the marks for written communication. Other answers in terms of the wavefronts arriving at the lens from distant objects with zero curvature, and the lens adding a constant curvature to form the real image, could also have gained credit.

(b) The distance of the screen from the lens is varied; the image is refocused by changing the object distance *u*. **Fig. 9.2 shows image height *h* with a ± 5% uncertainty, plotted against image distance *v*.**  **Fig. 9.2** **(i) Draw accurately the lines of best, maximum and minimum possible slope through the data points on Fig. 9.2.** **[1]**

Candidate style answer	*Examiner's commentary*
 	

(ii) State the best estimate and the range of possible values of the intercept on the horizontal axis. **[2]**

Candidate style answer	*Examiner's commentary*

`best intercept = .0.10....m`
 	
`intercept range from`
`.0.09... to .......0.11......m`
	Strictly the line of greatest slope should go through the lower uncertainty bar of point with smallest *v* value, and through the upper uncertainty bar of the point with the largest *v* value. You need a very sharp pencil to draw

	these accurately; and vice versa for the line of least slope. We cannot expect to read the intercepts to better than ½ a small graph square, so 0.10 ± 0.01 m is the best range estimate, from 0.09 to 0.11 m

(c)(i) Explain why this intercept is equal to the focal length *f* of the lens. **[1]**	
Candidate style answer	*Examiner's commentary*
`The closest the image can form to a converging lens is the focal length and occurs when the object is at infinity, and wavefronts are arriving at the lens with zero curvature. This occurs as a point image of zero height.`	This is a very complete answer; full marks could have been gained without mentioning the lack of curvature of the waves arriving from the distant object.

(ii) State the power of the lens with an estimate of its uncertainty. **Use data from (b), making your method clear.** **[4]** **[Total: 11]**	
Candidate style answer	*Examiner's commentary*

`P = 1 / f = 1 / 0.10 = 10 D`
 	
`Uncertainty estimates for the intercept are ± 10% due to small value and size of graph squares. So uncertainty in P is also about 10% or 1 D.`
 	
`power of lens = .....10..... ± ....1........ D`
	The power estimate is correct. Although the uncertainty estimate is double the % uncertainty in h, it is an acceptable answer for the reason given. Answers at half this level, at ± 5% or ± 0.05 D would also be acceptable, but possibly a little optimistic? Remember uncertainties are only sensible estimates, not hard numbers that everyone would absolutely agree with, don't fall into the trap of being too optimistic about uncertainty estimates.

10 Fig. 10.1 shows how the resistance of a thermistor varies with temperature.∆

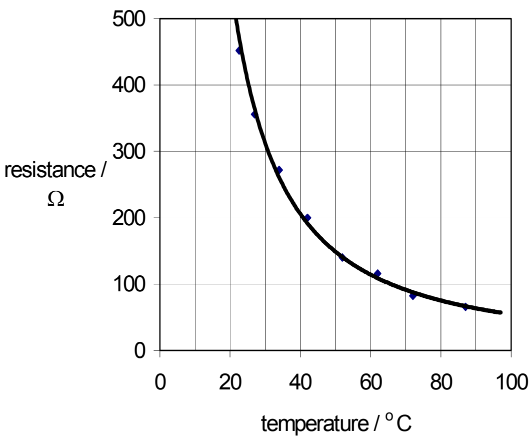


Fig. 10.1

(a) Use the graph to describe in detail how the resistance varies with temperature, and

to illustrate the meaning of the term sensitivity.

✎ **You will be awarded marks for the quality of your written communication.**

[4]

Candidate style answer	*Examiner's commentary*

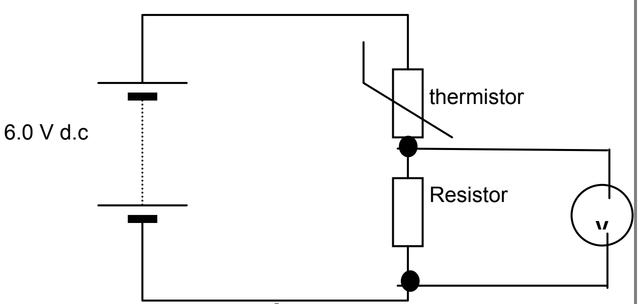
`At low temperatures the resistance drop is large for small equal temperature decreases.`
`At higher temperatures the resistance drop decreases for the same temperature change.`
 	
`The sensitivity is the |gradient of graph| = ΔR / ΔT so the sensitivity starts high and decreases.`
	The candidate has chosen his words and symbols carefully and correctly. The organisation of the answer clearly gains the quality of written communication mark.
	Notice that the gradient value actually **increases** from about -25 Ω °C^{-1} to -2 Ω °C^{-1}.
	So the modulus of the gradient is important here to get the sense of the sensitivity change correct. Clearly giving a sensible estimate of the value of the sensitivity at the low and high temperature ends of the scale is a good way of answering this question, Physicists like being quantitative whenever possible!

(b) Fig. 10.2 shows this thermistor together with a resistor in a temperature sensing potential divider circuit.

(i) A voltmeter is to be connected to the circuit to indicate an increasing p.d. when the sensor detects an increasing temperature.

On Fig. 10.2 draw the circuit connections for a voltmeter to measure a p.d. that rises with increasing temperature.

[1]

Candidate style answer	*Examiner's commentary*
 **Fig. 10.2**	The voltmeter is correctly placed across the fixed resistor; as the resistance of the thermistor falls with increasing temperature so will its fraction of the supply voltage in the potential divider. So the voltage across the fixed resistor must be rising, since the sum of the two voltages remains constant at 6.0 V the supply voltage. Therefore the voltmeter must be placed across the fixed resistor.

(ii) The value of the resistor in Fig. 10.2 is 200 Ω. The thermistor is at 65 °C.
Show that the current drawn from the 6.0 V supply is about 20 mA.
Use data from Fig. 10.1.

[3]

Candidate style answer	*Examiner's commentary*
$R_{thermistor}$ = 100 Ω from graph R_{total} = 100 + 200 = 300 Ω I = V / R_{total} = 6.0 / 300 = 0.020 A which is 20 mA	This is a good clear answer. Remember that a potential divider circuit is made of two resistors connected in series. Resistors in series add up, so the total resistance of the circuit is easy to find, once the thermistor resistance, at the specified temperature of 65 °C, has been read from the graph. The current can then be

	calculated from: I = *supply* voltage / total resistance.

(c) The graphs X, Y and Z in Fig. 10.3 show how the p.d. across the resistor varies with temperature, for three different values of the resistor.

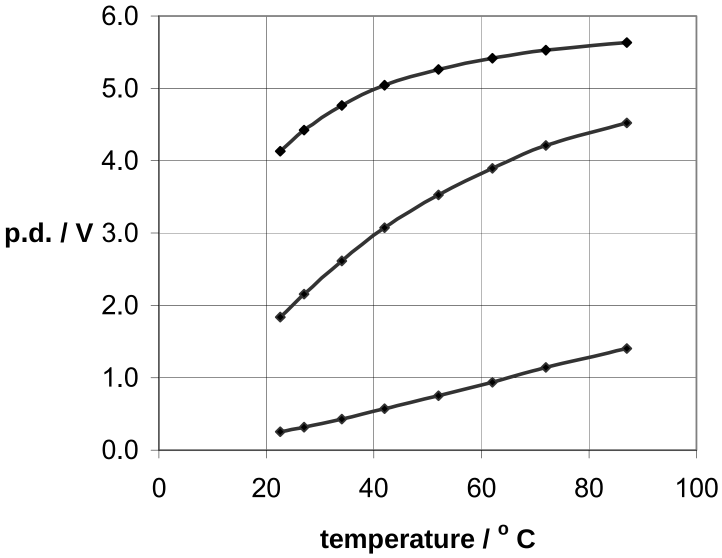


Fig. 10.3

(i) The values of resistance used are 20 Ω, 200 Ω and 1000 Ω.

State which graph, X, Y or Z, is the curve for the 1000 Ω resistor.

[1]

Candidate style answer	*Examiner's commentary*
X	Since the circuit output p.d. is across the resistor the higher the resistance value, the greater the fraction of the supply p.d. will be output. The graph with the greatest output signal **X** is therefore the correct choice.

(ii) State one advantage and one disadvantage of using output Z for the temperature sensing circuit.

[2]

[Total: 10]

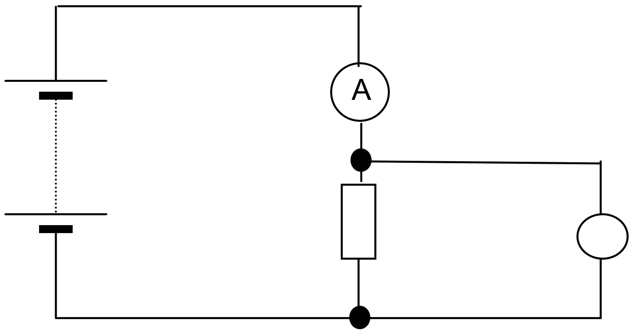
Candidate style answer	*Examiner's commentary*

`It is an advantage to work with a sensing circuit with constant sensitivity (graph gradient), and` ***Z*** `has a nearly linear output of constant gradient across this temperature range.`
 	
`A disadvantage is that the range of output values for` **Z** `is relatively small, just over 1.0 V, so the temperature resolution with a fairly insensitive voltmeter might be rather small.`
	These are very good answers showing a strong understanding of the physics of sensing circuits.

11 This question is about an experiment to measure either the electrical resistivity or the electrical conductivity of a highly conducting material of your choice. **(a) (i) State the material and circle the physical property above that you have chosen.** **[1]**	
Candidate style answer	*Examiner's commentary*
`Material nichrome alloy (a good conductor but used to make wire resistors)`	Correct answer.

(ii) The experiment would usually be performed on a long and thin sample of the material, such as a wire. **Justify this shape of the sample for your experiment.** **[2]**	
Candidate style answer	*Examiner's commentary*
In order to achieve an easily measurable resistance of a good conductor, i.e. several Ohms or tens of Ohms. The resistance needs to be long ($R \propto L$) and of small x-sectional area ($R \propto 1/A$) to build up the resistance value and avoid over large currents being drawn by the sample from low supply p.d.s. These may heat the metal and change its temperature and resistivity.	The candidate demonstrates good practical sense and fully justifies the choice of specimen shape, using physics ideas. The answer would have achieved full marks even without mention of the problem of warming the specimen, since two good physics points had already been made.

(iii) Describe with the help of a labelled diagram the equipment and method you would use to make your measurement.



[3]

Candidate style answer	*Examiner's commentary*
A pair of current and voltage readings lead to a measure of the resistance (R = V / I). The length L and diameter d can be taken using a metre rule (to nearest mm) and a micrometer gauge (to nearest 0.01mm). Then the x-sectional area could be calculated from $A = \pi\ (d^2 / 4)$. Finally resistivity $\rho = R\ A / L$	The circuit diagram is correct, ammeter in series and voltmeter in parallel with the specimen to be measured. The method is brief but mentions all the details and equipment needed to take the measurements and how to calculate the resistivity, so must gain full marks.

(b) Suggest an experimental difficulty that needs to be overcome, in limiting the uncertainty in the measurement of your chosen property. Describe how this difficulty can be overcome in practice.

✐ ***You will be awarded marks for the quality of your written communication.***

[3]

Candidate style answer	*Examiner's commentary*
The most difficult measurement to make in terms of % uncertainty is the diameter d of the wire. Typically the diameter is around 1 mm so to achieve a ± 1% uncertainty the measuring device must be capable of measuring to ± 0.01 mm. The micrometer screw gauge can achieve this, and several diameters should be measured to check for uniformity, repeatability and to estimate the mean and the spread in diameter values.	Correct answer.

(c) State the quantities, other than sample dimensions, that you need to measure to complete your calculation of the resistivity or conductivity.

[1]

[Total: 9]

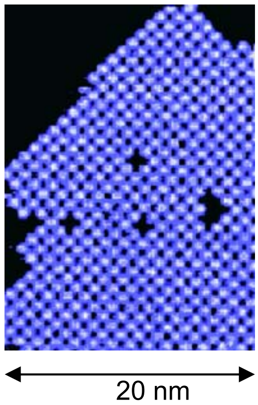
Candidate style answer	*Examiner's commentary*
The electrical resistance is required (R = V / I) for substitution into ρ	The candidate's logical thinking is clearly set out, much briefer answers mentioning only

= R A / L. The other quantities are the voltage across and current through the wire specimen taken at the same time; or the gradient of the proportional V / I graph for the wire specimen.	current and p.d. measurements would also secure this easy mark at the end of the question.

12 This question is about two methods of estimating the size of a molecule.

(a) This is the first method.

Fig. 12.1 is an STM (scanning tunnelling microscope) image of a layer of molecules. The field of view is 20 nm wide.



20 nm

Fig. 12.1

Estimate the size of a molecule using this information.

[2]

Candidate style answer	*Examiner's commentary*
About 15 molecules fit across the 20 nm scale marker. An estimate of the diameter of each molecule is therefore 20 nm / 15 = 1.33333 nm molecular size = .1.333 x 10^{-9} .m	The candidate has the correct method and evaluation, but will only score minimal marks! Because this is an estimate question and the final answer is given to 4 S.F. precision, which is unjustifiable in this example. Estimates should normally be given to 1 or 2 max S.F.

(b) Another method is to allow one drop of oil to spread out on a water surface.

(i) The oil drop has a diameter of 0.50 mm.

Show that the volume of oil in the drop is about 0.07 mm^3.

$$\textbf{Volume of sphere} = \frac{4}{3}\pi r^3$$

[2]

Candidate style answer	*Examiner's commentary*
$V = 4/3\ \pi\ (0.025\ )^3 \approx 0.07\ mm^3$	The candidate has the correct method for getting the volume out in mm^3, but only scores minimal marks for the method, since there is no evidence that the calculation has been performed or checked. Correct evaluation shows that V = 0.065 mm^3 to 2 S.F. and this

	should be stated to complete the "show that" type answer i.e. ≈ 0.07 mm^3 when expressed to 1 S.F.

(ii) When the oil spreads out on the water surface it forms a circular patch.

This is assumed to be one molecule thick. Therefore the thickness of the patch gives an estimate of the size of the molecule.

The diameter of the patch can be measured because the oil has moved aside powder scattered on the water surface as illustrated in Fig. 12.2.
question

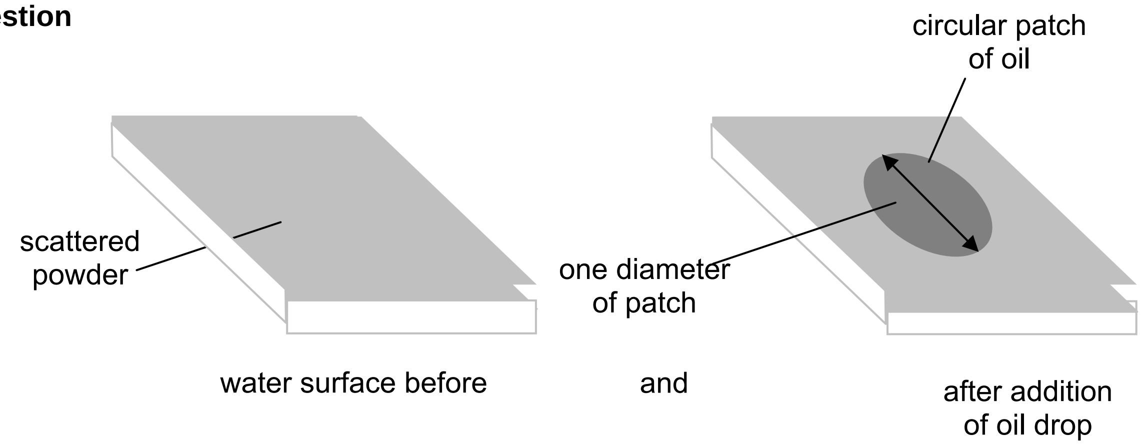


Fig.12.2

The diameter of the patch is measured in four different directions.

The results are given below.

diameter / mm	300	280	280	260

Calculate the mean diameter of the patch from these measurements.

[1]

Candidate style answer	*Examiner's commentary*
(300 + 280 + 280 + 260) / 4 = (1120) / 4 = 280 mm mean diameter = ….280 …mm	The candidate has shown the correct method and calculated the correct answer.

(iii) **For a patch of area *A* and thickness *h* the volume = A *h*.** **Calculate an estimate of the size of an oil molecule using the data from parts (b)(i) and (b)(iii).** **You may assume that the patch of oil is one molecule thick.** **[3]** **[Total 8]** **Total Section B [39]** **Paper Total [60]**	
Candidate style answer	*Examiner's commentary*
Volume of patch = Volume of drop $\pi (280 / 2)^2 \times h = 0.07$ working in mm^3 $h = 0.07 / 6.2 \times 10^4 = 1.1 \times 10^{-6}$ mm estimate of molecular size = 1.1×10^{-9} … m	This is a good clear method for estimating molecular size, although it uses the "show that" value for the drop volume of 0.07 mm^3, there is no error in the method or the arithmetic so the answer gains the full marks.

Overall banding: High

This candidate has shown a very good command of the AS level physics, the errors are few and relatively minor, more in the way of silly slips or lacks in exam technique. The candidate would be awarded a very good grade on the basis of these answers.