Advanced subsidiary GCE Physics B

Unit G491 Physics in Action - Medium 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.

<table>
<tr><td colspan="2">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]</td></tr>
<tr><td>Candidate style answer</td><td>Examiner's commentary</td></tr>
<tr><td>(a) electric current. A s
(b) resistance. V A^{-1}
(c) potential difference J s $^{-1}$</td><td>Only (b) has the correct answer. If you cannot remember the unit for a quantity,
go back to the defining equation which shows its relationships to other quantities.

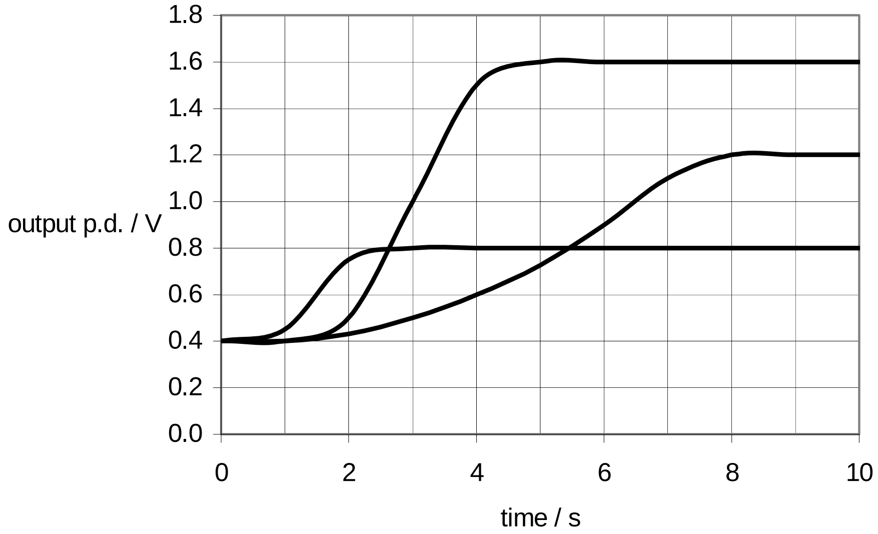
So here: current = charge per time ($I = Q / t$) ; so C s^{-1}

resistance = p.d. / current ($R = V / I$) ;

p.d. = energy change per charge ($V = E / Q$) ; so J C^{-1}

Then the unit equivalents for the Amp, Ohm and Volt should be apparent.</td></tr>
</table>

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.`	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). In **(a)** **B** is correctly the slowest to respond, and has the longest response time.

(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 = 0.40 unit V s-1`	The student has remembered that the sensitivity of a sensor is the gradient of a graph, but has chosen the wrong graph and confused the x-variable as time. The graph in the question has been used incorrectly, instead of a voltage vs temperature graph which needs to be imagined, using the 80 °C temperature rise given. In **(b)** the candidate would score zero. For an electrical sensor, the sensitivity is defined as: sensitivity = change in electrical output / change in physical variable measured = ΔV /

	ΔT 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.

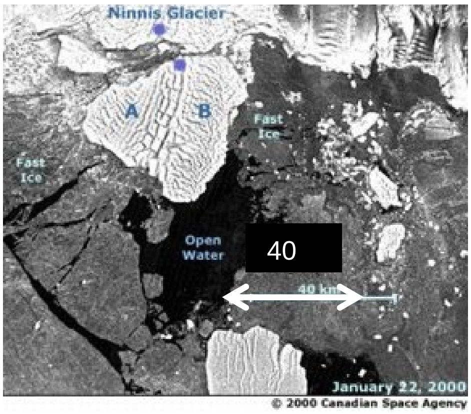


Fig. 3.1

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 is about ⅓ of 300 pixels`
`40 km is 100 pixels`
`0.40 km per pixel`
 	
`resolution = ……400…... m pixel-1`
	This is an acceptable estimated answer, and 1 S.F. is adequate precision.

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

[1]

Candidate style answer	*Examiner's commentary*

`movement about ½ marker`
 	
`distance = …….20 ……..  km`
	This estimate is within tolerance and would get the mark, the method is brief but has not been targeted for a mark in this question. 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*
`Wildlife might not survive.`	The candidate is too brief and has not addressed the question about the importance to humans of wildlife, so the answer would score zero. If the candidate had mentioned a consequence to humans such as maintaining

	bio-diversity, the mark could have been awarded.

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

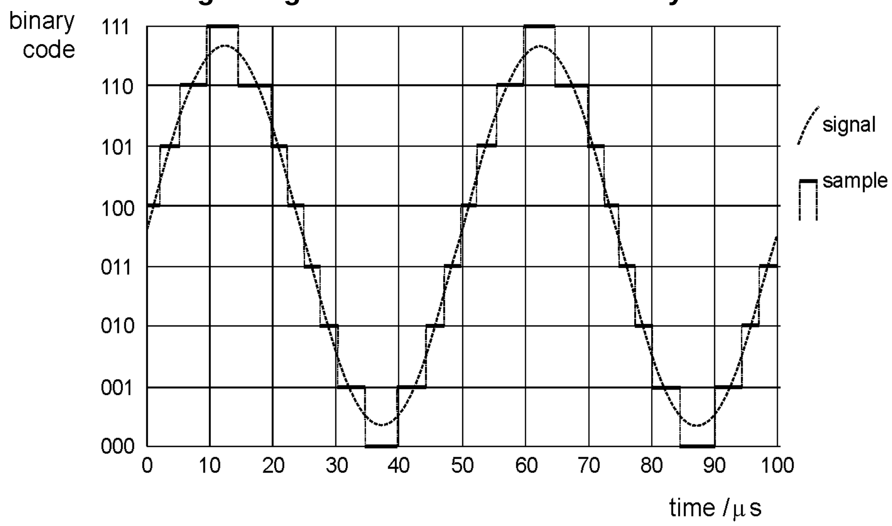


Fig. 4.1

(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 = ……...25………… µs	The candidate has incorrectly identified the time period from the waveform in (ai), having chosen the time for half a cycle of the whistle, and so loses the first mark.

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

[1]

Candidate style answer	*Examiner's commentary*
frequency = 1 / time period = 1 / 25 f = ……..0.04.…….. Hz	In (aii) a common error has been made, by ignoring the µ (micro) multiplier on the time axis. The candidate could have scored marks by e.c.f. (error carried forward) with the answer 40 000 Hz, but has made another error. 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 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*
3.0 / 0.5 = 6 maximum number of bits per sample =6.	The candidate's method is wrong, only the original signal to noise ratio has been calculated. The noise is about 1/7 of the amplitude of the total signal ($\approx$ 0.5 / 3.5), so there is no point in having the resolution finer than this. Remember in binary coding: alternatives = 2^{bits} 7 intervals needs 8 alternative levels of coding, since 2^3 = 8, 3 bits is sufficient.

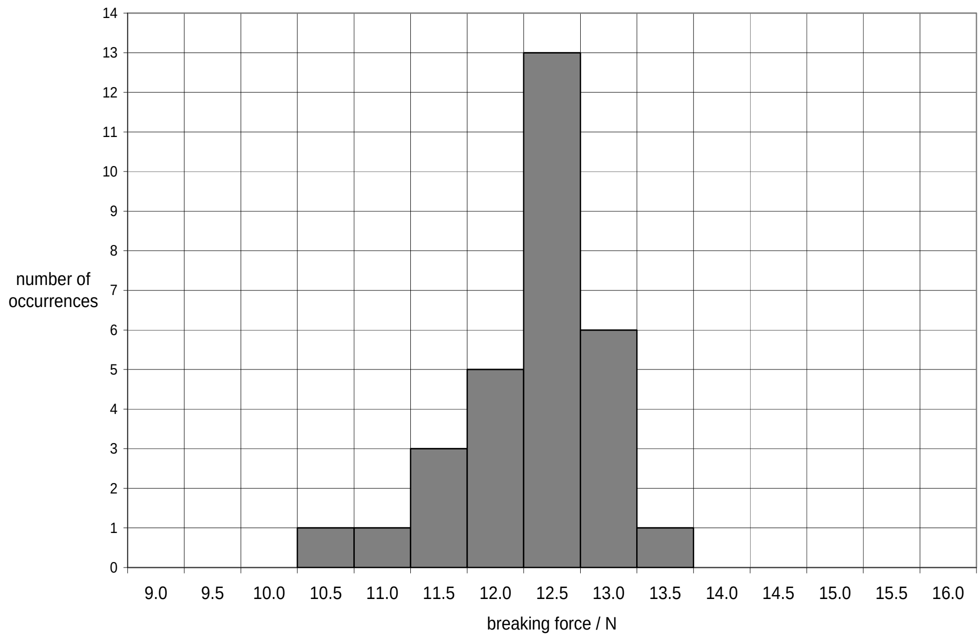
6 Here are five mechanical properties of materials **elasticity hardness toughness stiffness strength** **For each of the following descriptions of mechanical properties of materials write down the property being described from the list.** **[2]**	
Candidate style answer	*Examiner's commentary*
the stress 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*
470 x 0.5 = 235 potential difference = ...235.....V	This response is typical of a weak candidate, if in doubt either multiply or divide the numbers given, with no reference to any equation or theory! The relationship between *P, V* and *R* is needed. If this is not known by rote you will need to combine the two GCSE relationships: $P = IV$ and $V = IR$ and eliminate the

	current I which is not known or required in this case. This gives power $P = (V/R) \times V = V^2 / R$ and $V = \sqrt{(P R)} = 15$ V as the correct answer.

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 = ± 3 N breaking force = ...12.3... ± .....3..N	The candidate's method for the mean is clear and correct and 3 S.F. in the final answer is acceptable here considering that data is gathered to nearest 0.5 N. In estimating the uncertainty, the candidate has incorrectly quoted the range of force values, i.e. 3 N. A 1 S.F. estimate for uncertainty would be acceptable, but the uncertainty should usually be expressed as ± ½ range of values, so in this case 1.5 N or 2 N to 1 S.F. and avoiding being over optimistic.

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.

filament lamp | lens | screen and image

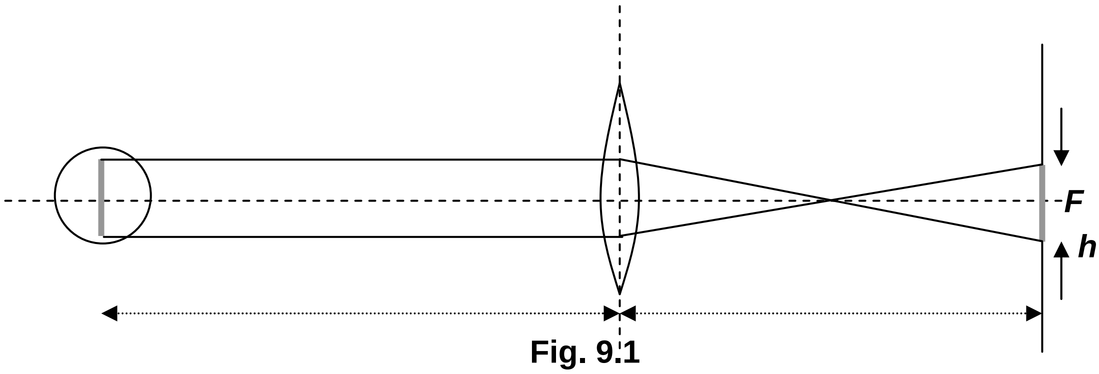
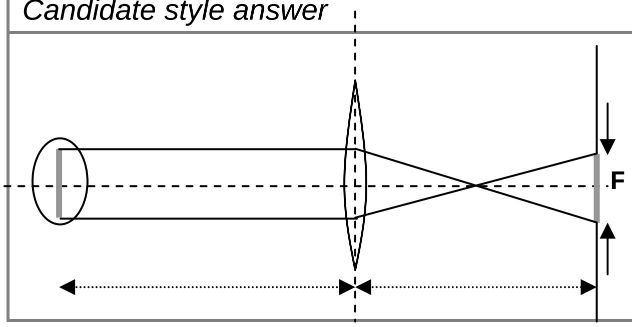


Fig. 9.1

u *v*

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

[1]

Candidate style answer	*Examiner's commentary*
	The candidate has marked **F** incorrectly in **(a)(i)**, the position where the image is formed has been confused with the focus of the lens (which is only the image position when the object is very distant from the lens).

(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*
`The image is formed by parallel rays from the object which cros at afinity forming a real object at F.`	In **(a)(ii)** the candidate has not shown a good command of technical English or spelling and the answer shows an incomplete grasp of the physics. Rays parallel to the axis of the lens will cross at the focus **F**, or rays arriving from one point on a very distant object arrive parallel at the lens. The candidate's first statement could be relevant for locating **F**, but the second statement shows that the candidate is very confused about the image and the object and it is irrelevant and contains spelling errors 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*.

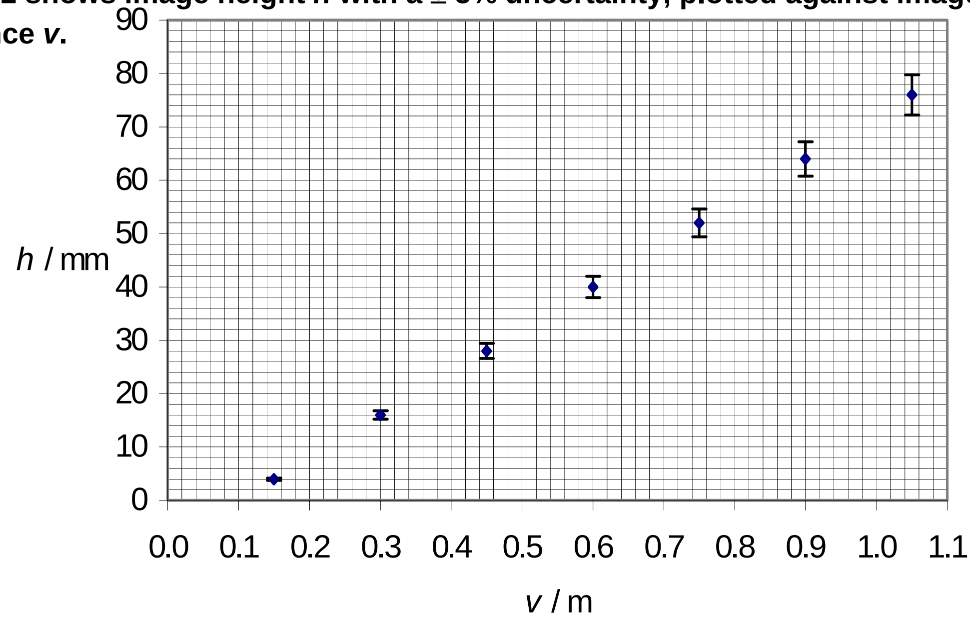
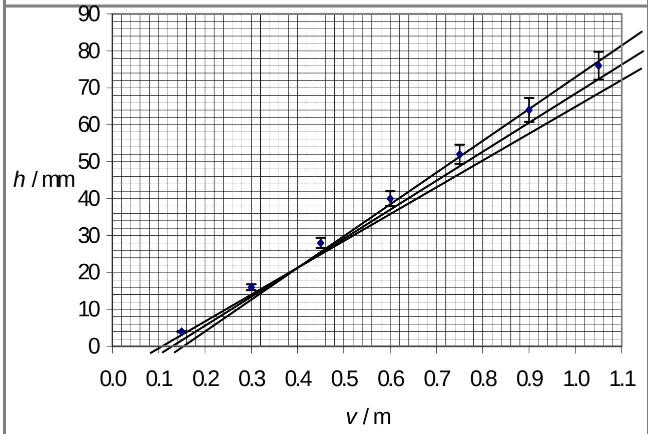


Fig. 9.2

(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*
	The candidate has correctly identified the line of best fit and the best intercept for the second mark. Lines of least and maximum slope have not been attempted, so the first and third marks are not available. 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, and vice versa for the line of least slope. You need a very sharp pencil to draw these accurately. We cannot expect to read intercepts to better than ½ a small graph square, so 0.10 ± 0.01 m would be a reasonable range estimate, from 0.09 to 0.11 m or ± 10%. A candidate who quoted the range at 0.095 to 0.105 m (± 5% uncertainty of the experiment) could also have been awarded the final mark.

(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	

(c)(i) Explain why this intercept is equal to the focal length *f* of the lens. [1]	
Candidate style answer	*Examiner's commentary*
The image has zero height.	This is the statement of a true fact, but does not constitute an explanation, so the mark would not be gained. The student would need to develop the idea more fully; by saying for instance that the image is smallest for a very distant object that is formed at the focal length of the lens.

(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 / 0.10 = 10 D Uncertainty is ± 5% power of lens = ...10....±.…0.5........D	The power and uncertainty estimates are correct, although it would have been nice to see the full equation quoted in the method (*P = 1 / f),* the candidate would probably be given benefit of the doubt. The uncertainty estimate at the ± 5% uncertainty in h, is an acceptable estimate, but is possibly a little optimistic? It is likely that there will also be some uncertainty in the values of the image distance *v* as well as in the image height *h* values. Remember uncertainties are only sensible estimates, not hard numbers that everyone would absolutely agree with; try not to 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.∆

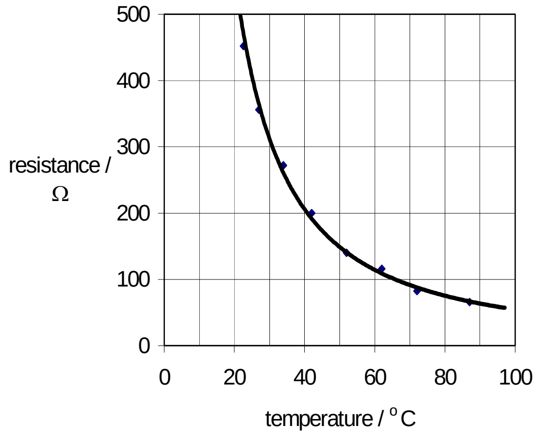


Fig. 10.1

(a) Use the graph to describe in detail how the resistance varies with temperature, and to illustrate the meaning of the term <u>sensitivity.</u>

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

[4]

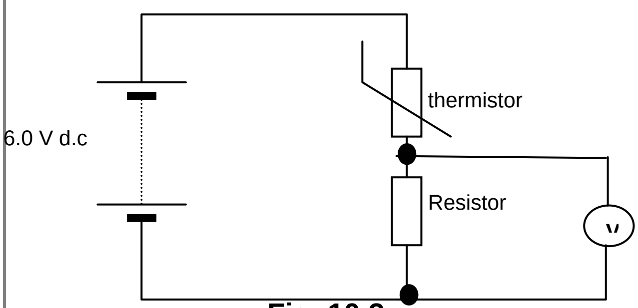
Candidate style answer	*Examiner's commentary*
`The resistance drops exponentially as the temperature rises and the sensitivity gets smaller.`	The candidate has written too briefly to expect high marks on a four mark question where quality of written communication is being tested! The candidate only gets the first easy mark for stating that the resistance drops as the temperature rises. The term exponential is generally over-used by candidates for any data showing negative correlation, and is incorrectly used here (no mathematical test has been applied to check for exponential variation and there doesn't appear to be an axis intercept). There is no attempt to explain or illustrate the meaning of sensitivity, so the quality mark for a well organised answer is also missing.

(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 = 100 total = 100 + 200 = 300 I = 6.0 / 300 = 0.020 A	This answer is not very well laid out (units are missing and equations used are not explicit, other than by the numbers representing concepts, neither is the resistance value read from the graph), but the answer is essentially correct for a "show that" question and should gain marks. 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 = V / R.

(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.

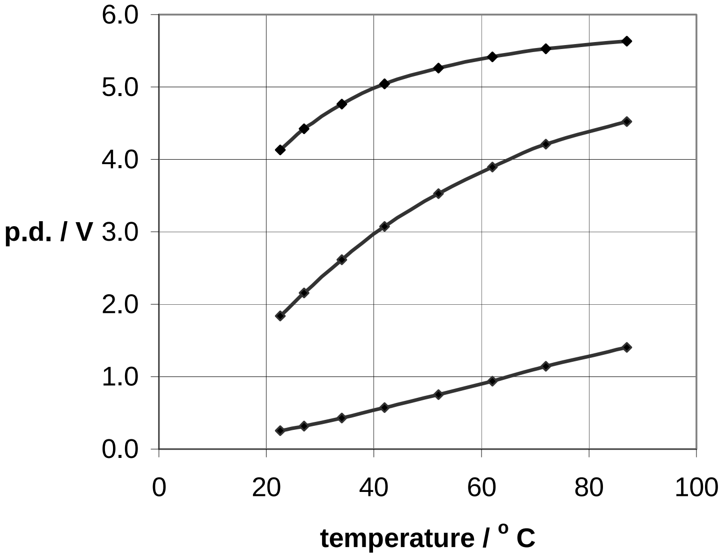


Fig. 10.3

(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]

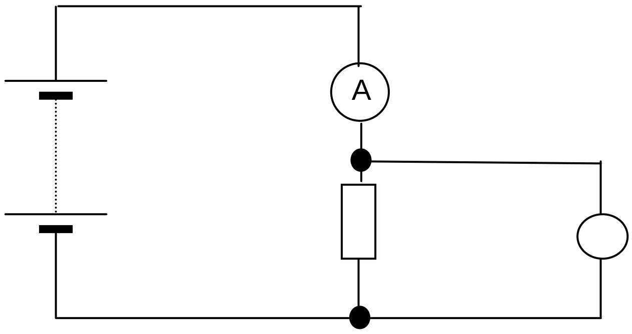
[Total: 10]

Candidate style answer	*Examiner's commentary*
`Th voltage is low but the graph is straight`	This is a poor response and would score few, if any, marks. It is not clear which is the advantage/disadvantage. The candidate needs to make it clear that the low output might be difficult to measure precisely with some voltmeters, and that the straight line graph means that sensitivity (gradient of the graph) is constant, which is very convenient in use.

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 ……copper……..	

(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*
to get a high resistance	The candidate has answered too briefly with a bare statement, certainly it could be the start of a good answer, but it is left unjustified. If the examiner had targeted a low level mark, then this might score 1/2, but for a medium or high level mark such a bare answer would not score at all. Since candidates do not know what level questions are targeted at, they should give the best and fullest answer that they can to each question. A better answer would go on to explain that copper is a very good conductor, in order to achieve an easily measurable resistance of several Ohms the resistance needs to be long ($R \propto L$) and of small x-sectional area ($R \propto 1/A$).

(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*

`current and voltage readings for conductance.`
`measure length L and diameter d`
`σ = G L / A`
	The circuit diagram is correct, ammeter in series and voltmeter in parallel with the specimen to be measured. The method is rather brief not mentioning what devices might be appropriate for measuring length and diameter; nor how the x-sectional area could be calculated from $A = \pi (d^2 / 4)$, it should be worth some further marks depending on the level targeted in the question. The formula quoted is given on the data and relationships sheet, so without further amplification is not worth a mark on its own.

(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 is the diameter d of the wire.` `Typically the diameter is small, around 1 mm or less, to get a high enough resistance. Use a micrometer screw gauge, and measure several diameters and take an average.`	The candidate has answered the question rather briefly, but there are no errors and the technical language is clear and several good points have been made if not fully explained. (The precision ± 0.01 mm of the micrometer could have been mentioned or the % uncertainty it would give rise to in the diameter or area). However the meaning is clear and correct and this answer should score high marks for physics content and the third mark for the quality of written communication.

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

[1]
[Total: 9]

Candidate style answer	*Examiner's commentary*
`the voltage across and current through`	The candidate answer is brief, but has

the wire	mentioned everything necessary and should gain 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.

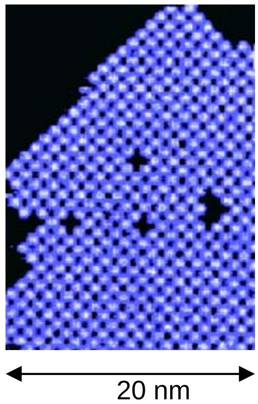


Fig. 12.1

Estimate the size of a molecule using this information.

[2]

Candidate style answer	*Examiner's commentary*
molecular size = ……2……. nm	The candidate has made a rough estimate of about 1/10 of the length of the distance marker and expressed the answer to 1 S.F. Since the method was not requested and the estimate is reasonable the candidate should secure marks. It is perfectly sensible to quote estimates to 1 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 π (0.025)^3 = 0.065 mm^3	The candidate has the correct method for getting the volume out in mm3 and it is clear that the calculation has been performed. Do not fall into the trap of not bothering to work out a "show that" calculation, by just quoting the usually rounded off value given.

(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

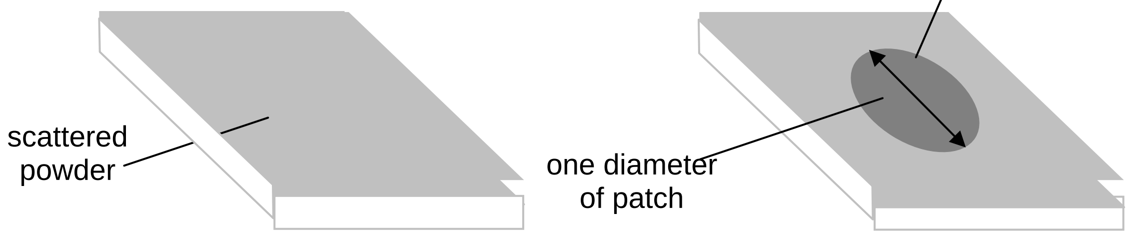


Fig.12.2

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*
`mean diameter  = ….280 mm`	The candidate has not shown the method but the answer is correct and so the mark should be awarded.

(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*
π (280 x 10-3)2 x h = 0.065 x 10-3 h = 0.065 x 10-3 / 0.25 = 2.6 x 10-4	This method for estimating molecular size is wrong, the candidate seems to have equated the volumes of drop and patch, but has used

`estimate of molecular size = 2.6 x 10-4 … m`
`π (280 / 2)2 x h = 0.07 working in mm3`
 	
`h = 0.07 / 6.2 x 104 = 1.1 x 10-6 mm`
 	
`estimate of molecular size =`
`1.1 x 10-9 … m`
	the wrong formulation for the volume of the patch πD^2 instead of πr^2, so even the method mark cannot be awarded. The evaluation is out by a factor of x 10^{-6}. There are also two distinct and serious further errors in the evaluation.
	
	The candidate has forgotten that 1 mm^3 = (1 x 10^{-3} m)^3 = 10^{-9} m^3 (NOT 1 mm^3 = 10^{-3} m^3)
	
	and also to half the diameter for the radius ($r = D / 2$) in using $A = \pi r^2$
	
	The candidate would score zero for this answer.

Overall banding: Medium

This candidate has shown a weak command of some the AS level physics, the errors are quite frequent and sometimes major, as well as some silly slips and lack of exam technique. The candidate would be awarded a middle grade on the basis of these answers.