**SPECIMEN**

**Advanced Subsidiary GCE**

**PHYSICS B (ADVANCING PHYSICS)**

# G491 QP

Unit G491: Physics in Action

**Specimen Paper**

Candidates answer on the question paper.

Additional Materials:
Data, Formulae and Relationships Booklet
Electronic calculator

Time: 1 hour

| | |
|---|---|
| Candidate Name | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Centre Number | | | | | | Candidate Number | | | | | |

**INSTRUCTIONS TO CANDIDATES**

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED.

**INFORMATION FOR CANDIDATES**

- The number of marks is given in brackets [] at the end of each question or part question.
- ✎ Where you see this icon you will be awarded marks for the quality of written communication in your answer.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- The total number of marks for this paper is **60**.

| FOR EXAMINER'S USE | | |
|---|---|---|
| **Section** | **Max.** | **Mark** |
| **A** | **21** | |
| **B** | **39** | |
| **TOTAL** | **60** | |

This document consists of **19** printed pages and **1** blank page.

Answer **all** the questions.

**Section A**

**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

**(a)** electric current ..................................................................................................................

..................................................................................................................

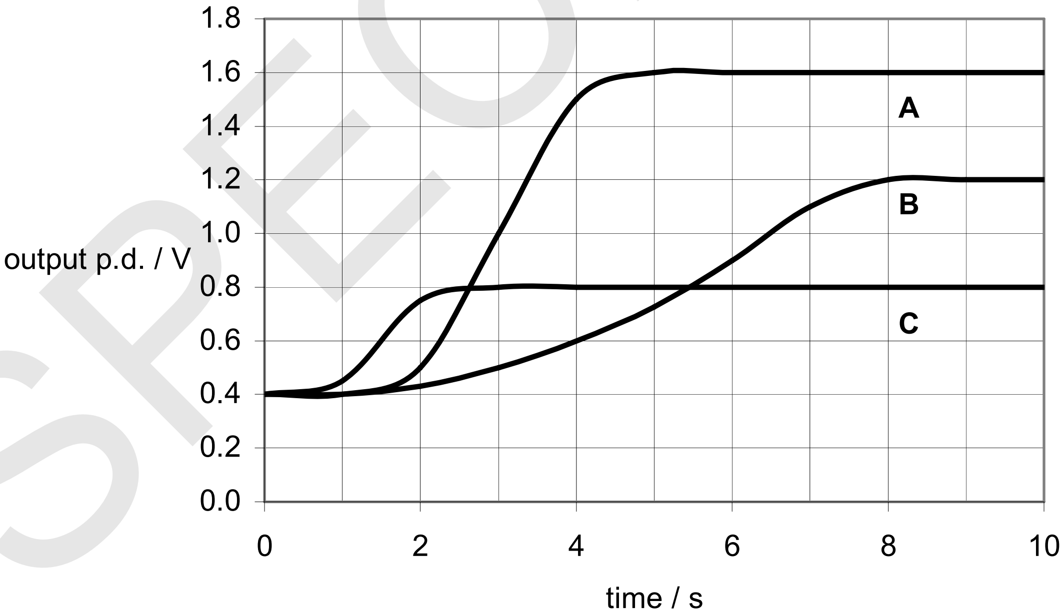
**(b)** resistance ..................................................................................................................

..................................................................................................................

**(c)** potential difference..................................................................................................................

.................................................................................................................. **[3]**

**2** Three temperature sensors **A, B** and **C** 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]**

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

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

sensitivity = ...................................................................................................unit **[2]**

**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.

resolution = ................................. m pixel$^{-1}$ **[1]**

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

distance ............................................... km **[1]**

**(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]**

**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.

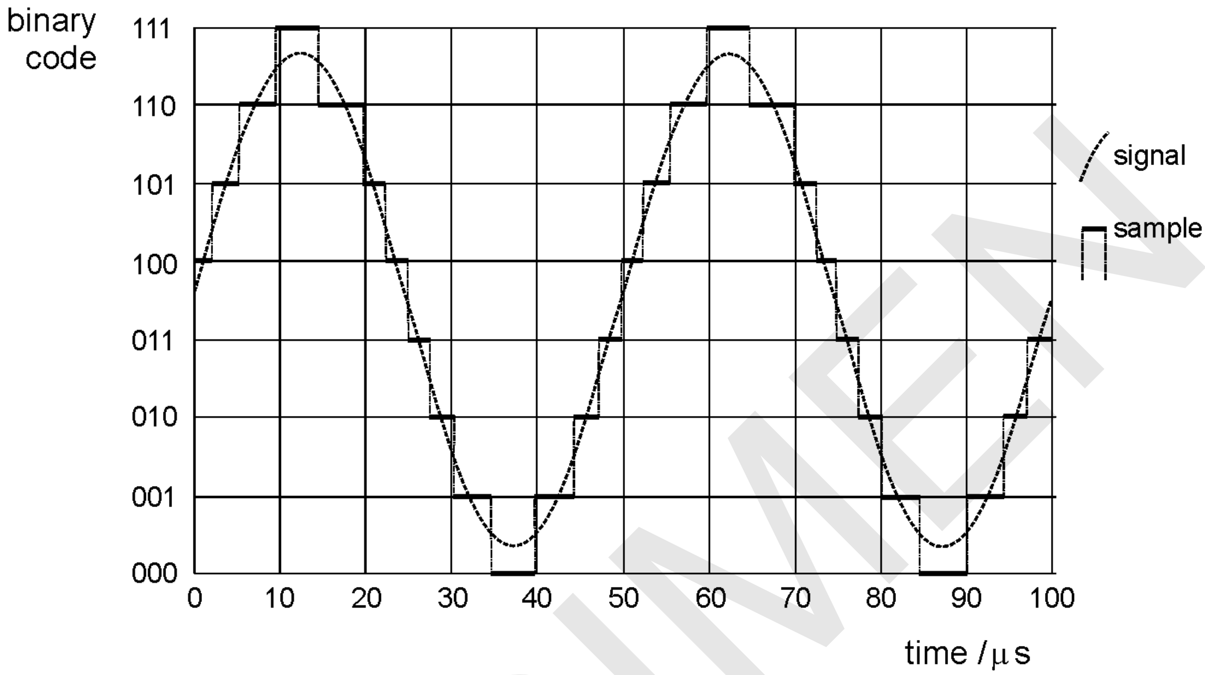



**Fig. 4.1**

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

*T* = ......................................................... μs **[1]**

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

*f* = ......................................................... Hz **[1]**

**(b)** The waveform is sampled every 1.0 μs.

Calculate the rate at which the sampled information is transmitted.

information rate = ........................... bits $s^{-1}$ **[2]**

**[Turn Over**

**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.

maximum number of bits per sample = .................................. **[1]**

**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.

The stress required to break a material ..........................................................................................

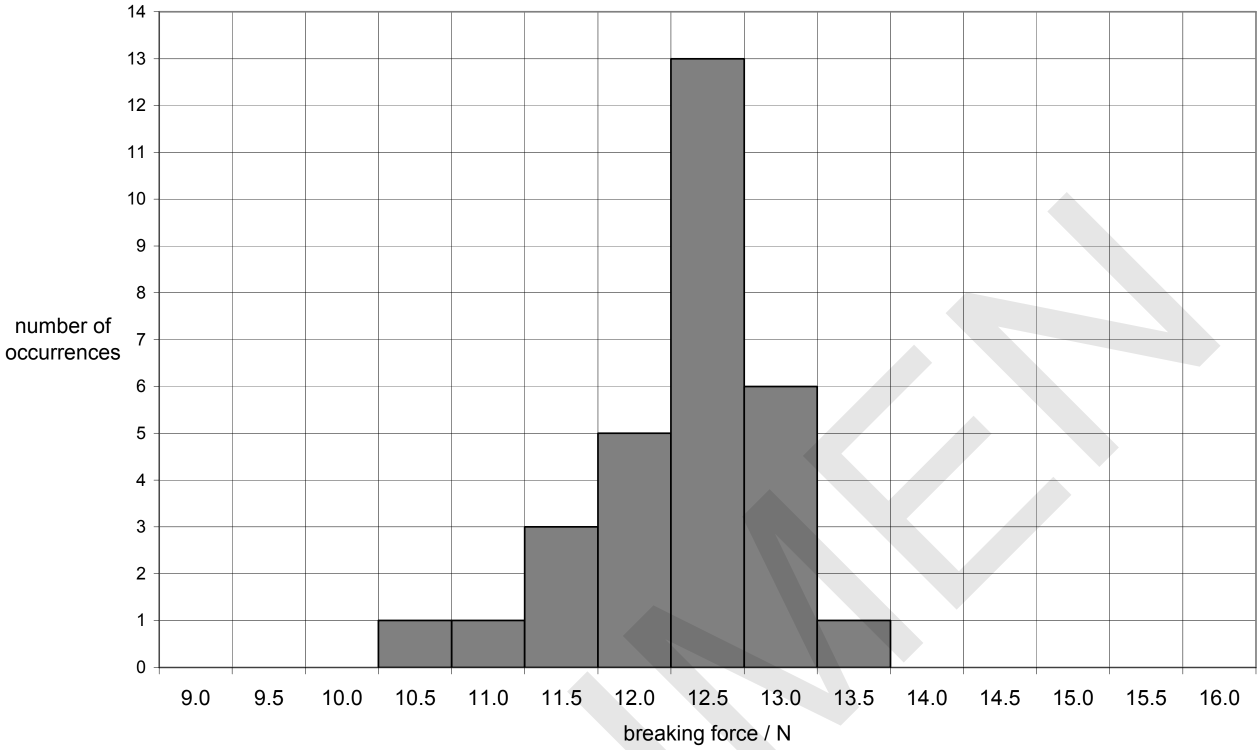
A measure of the difficulty of scratching or denting the material .................................................. **[2]**

**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.

potential difference = ............................... V **[2]**

**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.

breaking force = ............... ± ............... N **[3]**

**Section A Total: [21]**

**[Turn Over**

## Section B

**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.

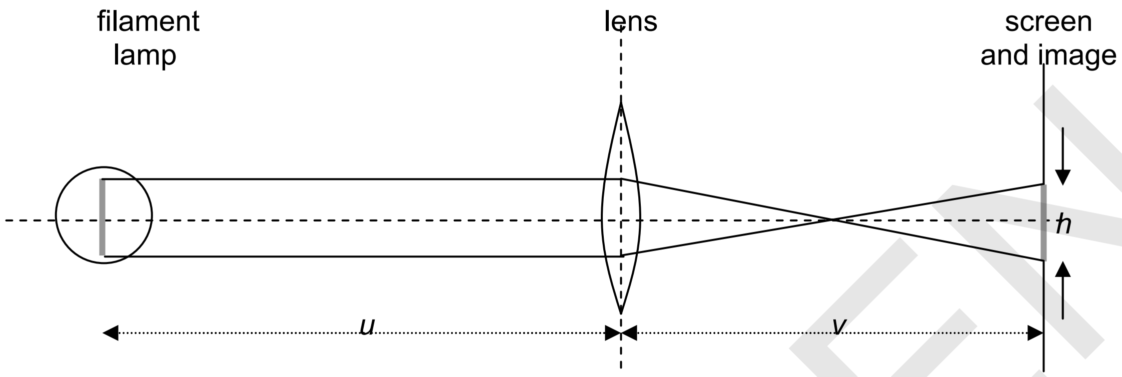



**Fig. 9.1**

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

**[1]**

**(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]**

**(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*.

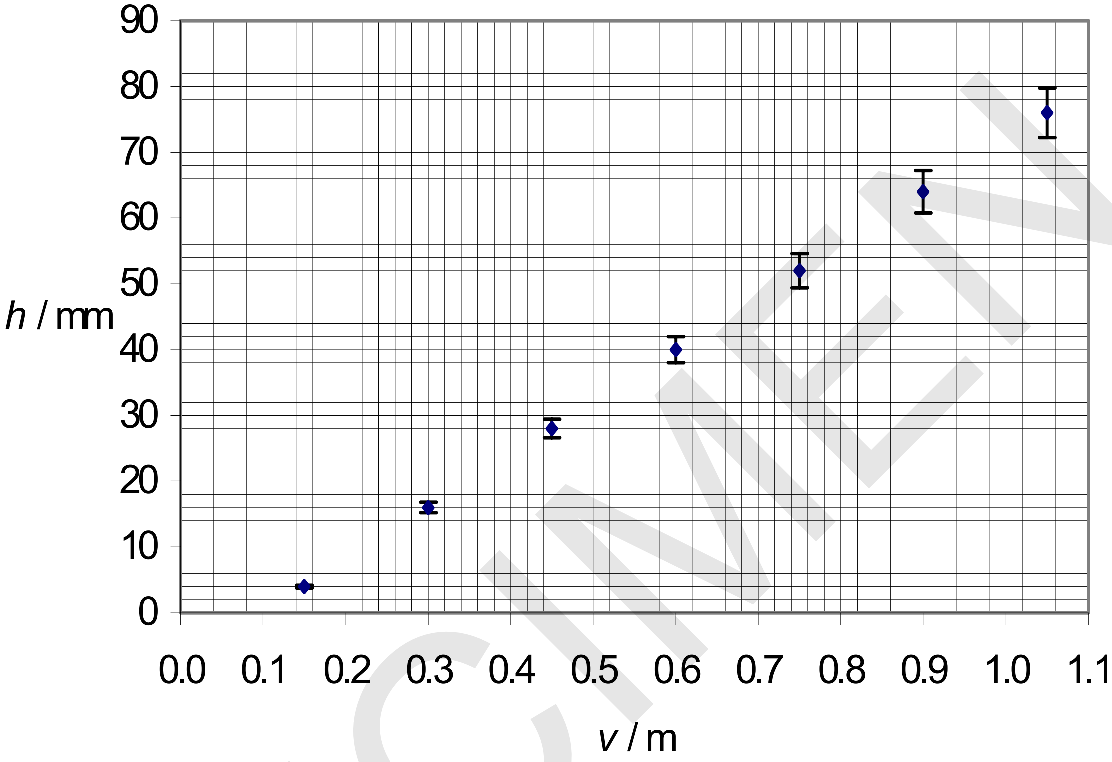



**Fig. 9.2**

**(i)** Draw accurately the lines of best, maximum and minimum possible slope through the data points on Fig. 9.2. **[1]**

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

best intercept = ............................................ m **[1]**

intercept range from ................ to .................. m **[1]**

**(c)** **(i)** Explain why this intercept is equal to the focal length *f* of the lens.

**[1]**

**(ii)** State the power of the lens with an estimate of its uncertainty.

Use data from **(b)**, making your method clear.

power of lens = ............... ± ..................D **[4]**

**[Total 11]**

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

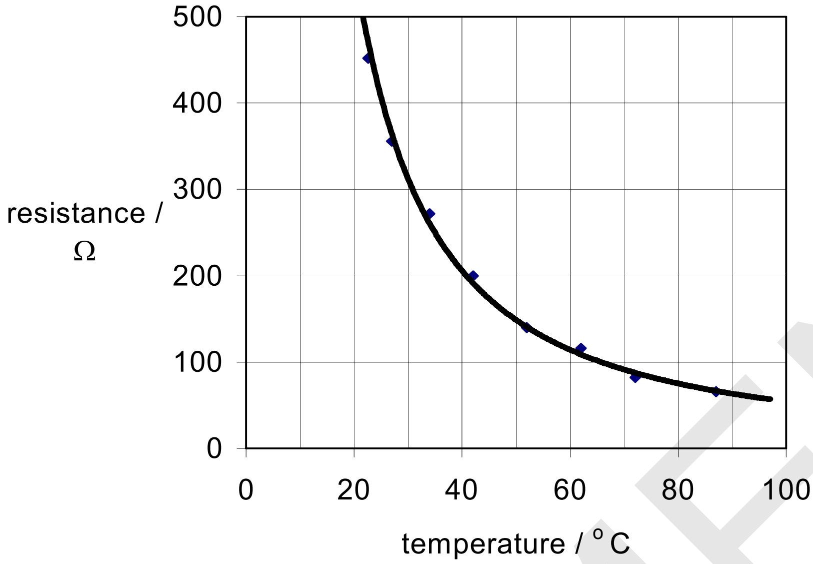



**Fig. 10.1**

**(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]**

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

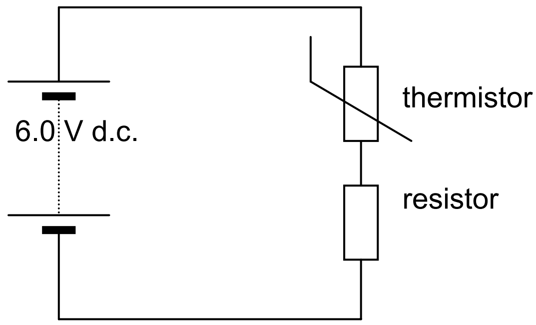



**Fig. 10.2**

**(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]**

**(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]**

**(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.

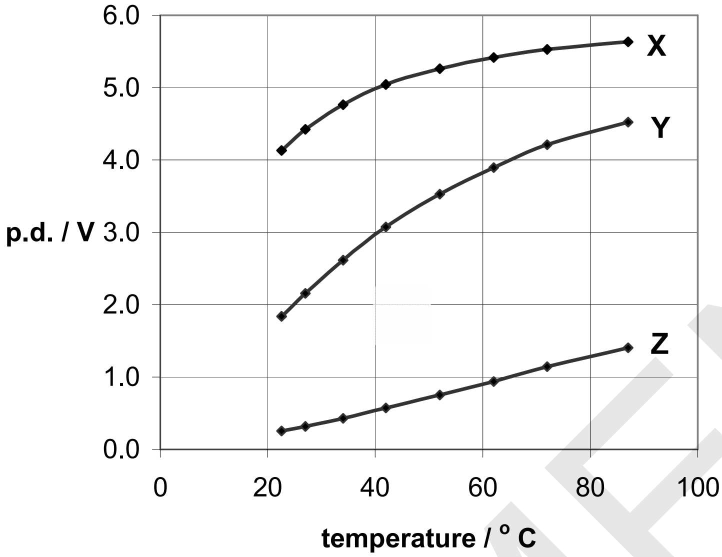



**Fig. 10.3**

**(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]**

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

**[2]**

**[Total : 10]**

**[Turn over**

**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.

Material ..............................................................................................................

**(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]**

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

**[3]**

**(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]**

**(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]**

**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.

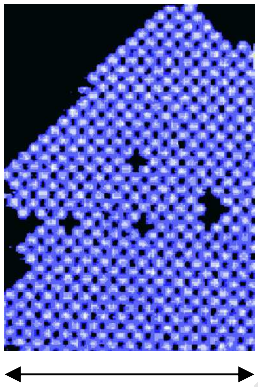



**Fig. 12.1** Courtesy of © Matthias Boehringer, University of Lausanne

Estimate the size of a molecule using this information.

molecular size = ..................................... m **[2]**

**(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 $mm^3$.

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

**[2]**

**(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.

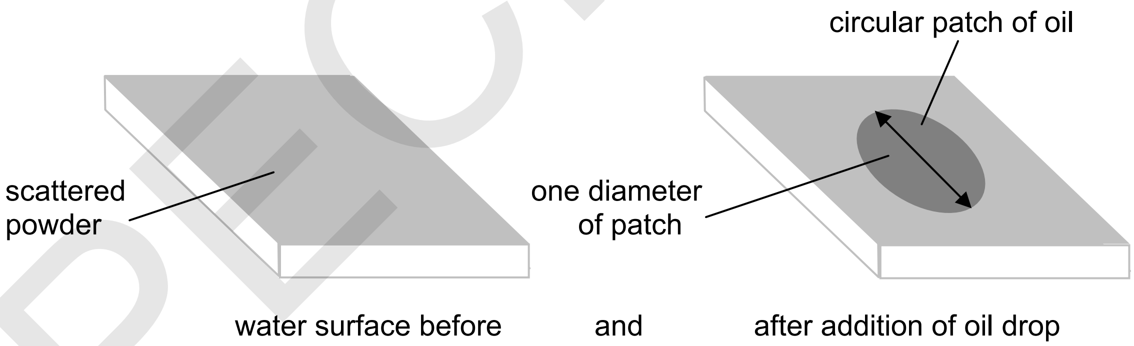



**Fig.12.2**

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.

mean diameter = ................................ mm **[1]**

**[Turn over**

**(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.

estimate of molecular size = ........................ m

**[3]**

**[Total 8]**

**Total Section B [39]**

**Paper Total [60]**

*Copyright Acknowledgements:*

*Sources*

**Figs 3.1 & 3.2** © 2000 Canadian Space Agency

**Fig 12.1** Courtesy of © Matthias Boehringer, University of Lausanne