Unit 6 – Year 13

Practice EMPA with model data provided.

Name _____

This is a past question paper of

Section A Task 1 (Question 2 only)

- You will be shown the equipment used and provided with an example set of results. You should then be able to complete this question independently. The graph you draw in this question is not referred to again.

Section A Task 2 (Question 1)

- You will be shown the equipment used and provided with an example set of results. You should then be able to complete this question independently. The graph you draw in this question is then required for the Section B written section.

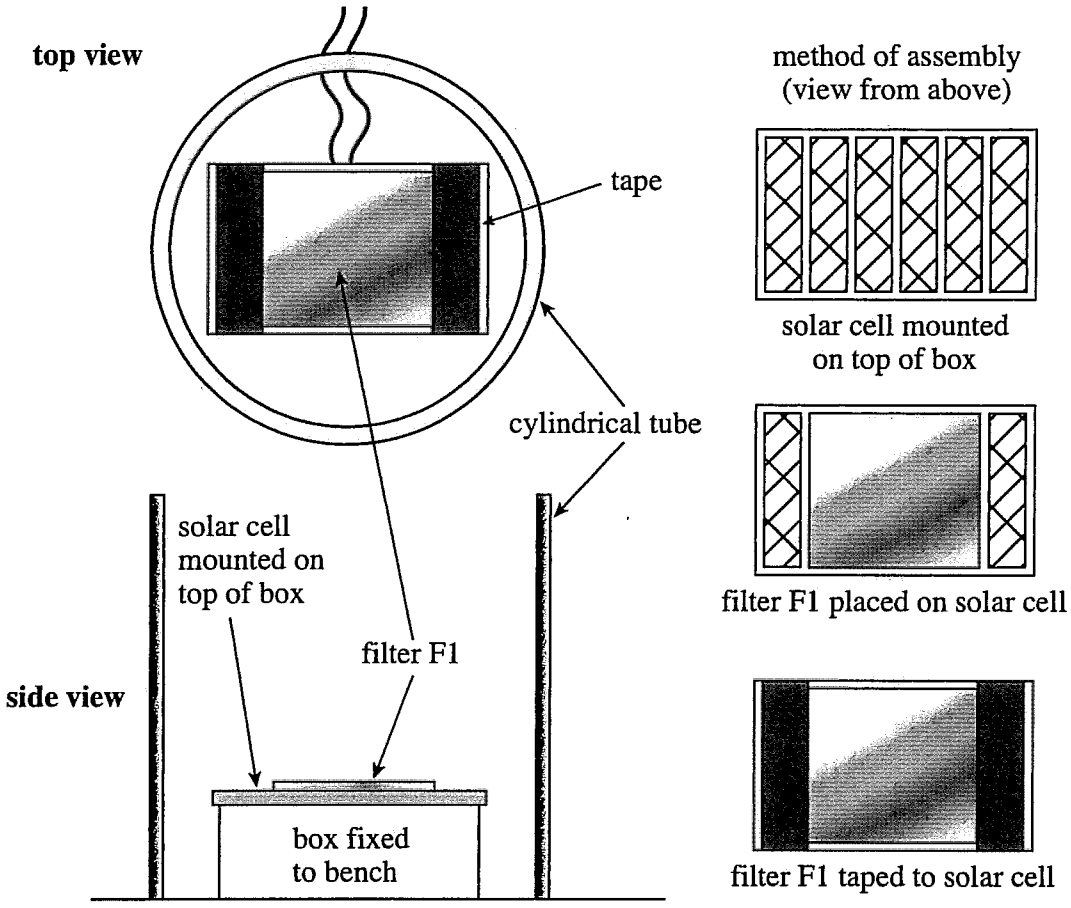
Section B

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

2 You are to measure the output voltage of a solar cell as the intensity of light incident on it is varied by passing the light through two identical polarising filters.
The general arrangement and method of assembly is shown in top and side view in **Figure 3**.

Figure 3



Filter F1 has been taped to the surface of the solar cell that is sensitive to light.
The cell has been mounted on a box which has been fixed to the bench.
A cylindrical tube has been placed around this arrangement to shield it from unwanted light.

Place the circular scale centrally on top of the cylindrical tube with the printed side uppermost and fix this to the tube using Blu-Tack.

Position the clamped light source so that the lamp is directly above the hole in the circular scale.
Do not adjust the height of the lamp or the output voltage of the power supply.

The filter F2 has been mounted between two pieces of circular card.

2 (a) (i) Position this card centrally on the circular scale so that θ, the direction of the arrow = 0°. Switch on the lamp then read and record the voltmeter reading V_0.

V_0 = 24.1

Question 2 continues on the next page

2 (a) (ii) Keeping the card centrally on the scale, increase θ in 20° steps to obtain further values of V to complete the table.
Switch off the lamp once you have completed these measurements.

θ / °	V / mV	θ / °	V / mV	θ / °	V / mV
20	23.2	140	21.8	260	15.2
40	20.4	160	24.2	280	15.8
60	16.9	180	24.9	300	18.3
80	15.0	200	23.4	320	22.0
100	15.6	220	20.6	340	24.4
120	18.1	240	17.1	360	25.1

(1 mark)

2 (b) Adding a suitable scale to the vertical axis, plot on the grid on **page 9** a graph of your results from part (a)(ii).

(2 marks)

2 (c) (i) Read from your graph, and record below, V_{max} and V_{min}, the maximum and minimum values of V.

V_{max} = ...

V_{min} = ...

2 (c) (ii) Hence estimate the amplitude, A, of the variation V with θ.

A = ...

2 (c) (iii) Identify and explain from your graph any value of θ for which the experimental arrangement is most sensitive to changes in θ.

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(3 marks)

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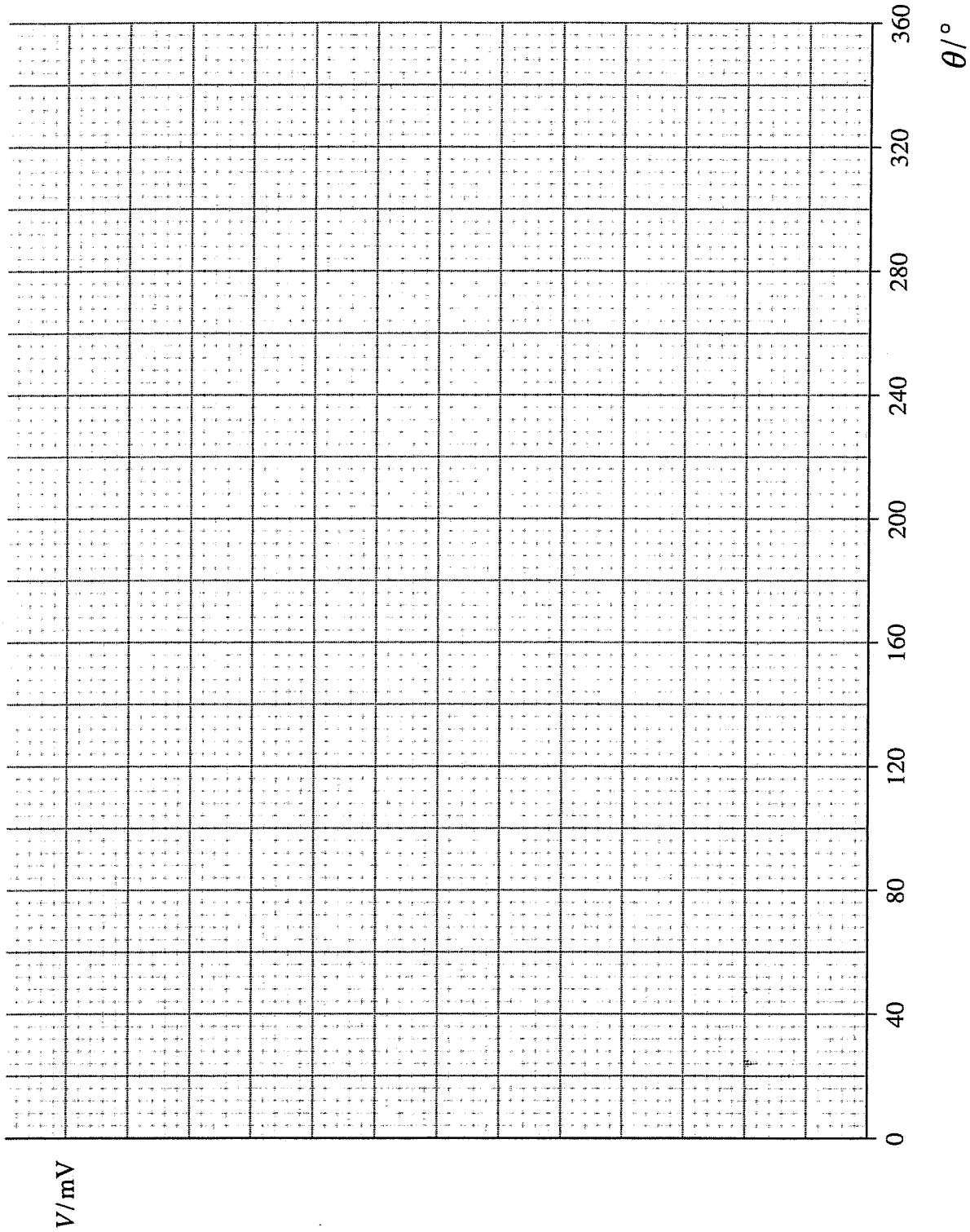

2 (d) A student performs the experiment but fails to keep the edge of the card containing the filter F2 centrally on the circular scale.

2 (d) (i) State and explain the effect this may have on the readings of V.

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2 (d) (ii) State **one** procedure that the student could take so that this error can be avoided.

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(3 marks)

9

END OF SECTION A PART 1

Section A Part 2

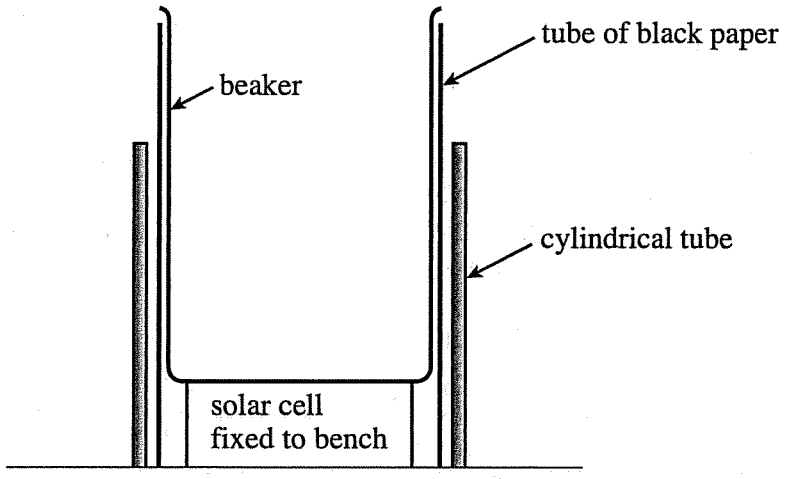
Follow the instructions given below.

Answer **all** the questions in the spaces provided.

No description of the experiment is required.

1 In this experiment you are to investigate the absorption of light as it passes through a solution of ink. The apparatus you will use is shown in **Figure 4**.

Figure 4



The solar cell and the cylindrical tube have been taped to the bench.
Do not remove the beaker or the tube of black paper from within the cylindrical tube.

Position the clamped lamp so that it is coaxial with the beaker.
Do not adjust the height of the lamp or the output voltage of the power supply.

The output voltage of the solar cell is shown on the digital voltmeter.
Do not change the range setting of the voltmeter.

Switch on the lamp and monitor the voltmeter reading over a short interval of time, eg 20 seconds, so that either the reading reaches a steady value or so you can determine the range, and hence the mean value, V_0, of the reading.

1 (a) Read and record V_0.

V_0 = 375 mV

(1 mark)

1 (b) You are provided with approximately 500 ml of a solution of ink and two measuring cylinders of different capacity and resolution.
You are to record the voltmeter reading, V, as the volume of ink solution in the beaker, Q, is varied.

1 (b) (i) Transfer **between 90 ml and 100 ml** of the solution to the **larger** measuring cylinder.
Note the volume of the solution in this measuring cylinder before carefully pouring this into the beaker.
Record Q, the volume of the solution in the beaker.
Read and record the (mean) voltmeter reading, V.

1 (b) (ii) Transfer between **20 ml and 25 ml** of the solution to the **smaller** measuring cylinder.
Note the volume of the solution in the measuring cylinder before carefully pouring this into the beaker.
Record Q, the new volume of the solution in the beaker then read and record the corresponding (mean) voltmeter reading, V.
Increase Q in increments of between 20 ml and 25 ml, recording the voltmeter reading, V, at each stage, until Q is about 200 ml.

1 (b) (iii) Transfer between **40 ml and 70 ml** of the solution to the **larger** measuring cylinder.
Note the volume of the solution in this measuring cylinder before carefully pouring this into the beaker.
Record Q and V then continue, increasing Q in increments of between 40 ml and 70 ml, measuring the voltmeter reading, V, at each stage, until all the solution has been transferred to the beaker.

You should record all the data required to complete part (b) of this question on **page 4** of this booklet.
Note that you will not be expected to record repeat readings of the measurements made in part (b).

Question 1 continues on the next page

Measurements and observations.

sample data - insert correct headings

0	375
95	348
117	338
140	334
162	329
186	324
200	319
260	305
320	290
380	279
440	263
500	251

(6 marks)

separate graph paper

1 (c) Plot, on the grid [illegible], a graph with ln(V/mV) on the vertical axis and Q on the horizontal axis. You should draw a straight line of best fit through the plotted points. Record below the data you will plot on your graph.

(9 marks)

END OF SECTION A PART 2

16

Section B

Answer **all** the questions in the spaces provided.

The time allowed is 1 hour 15 minutes.

You will need to refer to the work you did in Section A Part 2 when answering these questions.

1 (a) (i) Determine the gradient, G, of your graph of $\ln(V/\text{mV})$ against Q.

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G = ...

1 (a) (ii) Read and record the vertical intercept from your graph.

vertical intercept = ...

(3 marks)

1 (b) A student claims that an analogy can be made between the experiment in which light is absorbed by the ink solution and an experiment in which ionising radiation is absorbed by different thicknesses of metal plates.
Using the analogy, she suggests that the output voltage of the solar cell, V, is given by

$$V = Pe^{-\lambda Q},$$

where P and λ are constants.

1 (b) (i) If the student's analogy is correct, describe the form that a graph of $\ln(V/\text{mV})$ against Q should take and explain how the values of P and λ may be deduced from the graph.

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1 (b) (ii) Explain whether the qualitative and quantitative evidence obtained from your graph confirms the student's analogy.

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(6 marks)

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Turn over for the next question

2 (a) (i) Describe **one** difficulty you experienced when measuring the volume of the ink solution.

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2 (a) (ii) Explain **one** precaution you took to reduce the uncertainty when measuring the volume of ink solution in the measuring cylinders.
You may wish to use a sketch to illustrate your answer.

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(2 marks)

2 (b) Having transferred between 90ml and 100 ml of ink solution to the beaker, students A and B did not follow the instructions about which measuring cylinders they should then use.
Student A used only the **larger** measuring cylinder (capacity 100 ml, 1 ml graduations).
Student B used only the **smaller** measuring cylinder (capacity 25 ml, 0.5 ml graduations).

2 (b) (i) Give a disadvantage of the procedure followed by student A.

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2 (b) (ii) Give a disadvantage of the procedure followed by student B.

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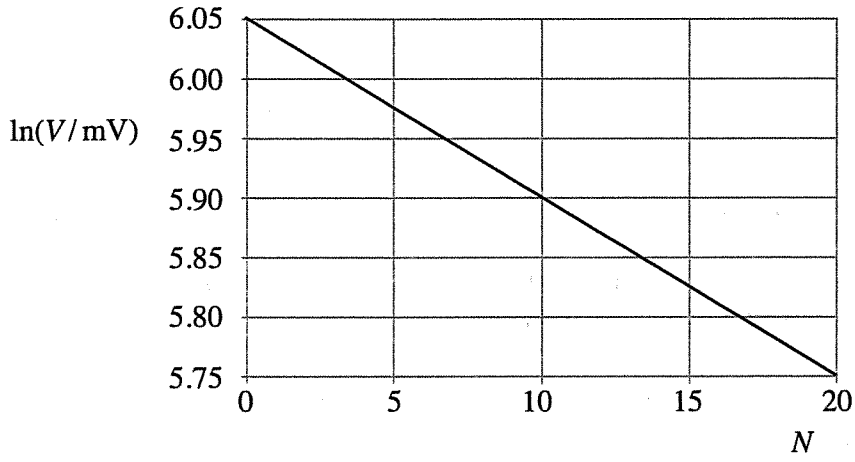
(2 marks)

4

3 A student adapts the experiment to investigate how light is absorbed by glass.
The student uses a varying number of glass microscope slides (up to a maximum of 20 slides) placed in a single stack on top of the solar cell to produce different thicknesses of the glass.

The student plots a graph of his results, as shown in **Figure 5**.
Note that N = number of glass microscope slides placed on top of the solar cell.

Figure 5



Assuming that the output voltage of the solar cell is directly proportional to the light intensity incident upon it, the student intends to determine the half-value thickness of glass, ie the thickness of glass that would reduce the output voltage by half.

3 (a) Use the information provided in the student's graph to calculate $N_{0.5}$, the value of N equivalent to the half-value thickness of the glass.

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(3 marks)

3 (b) To determine the half-value thickness of the glass in mm, the student needs to make one additional measurement.

3 (b) (i) Identify the measurement the student needs to make and explain how this is used to determine the half-value thickness of the glass.

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The student uses a micrometer screw gauge to make the additional measurement.

3 (b) (ii) Identify **one** procedure that can be used to reduce the effect of random errors when making the measurement.

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3 (b) (iii) Identify **one** procedure that can be used to detect, and hence correct, for possible systematic errors in the measurements made with the micrometer screw gauge.

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(3 marks)

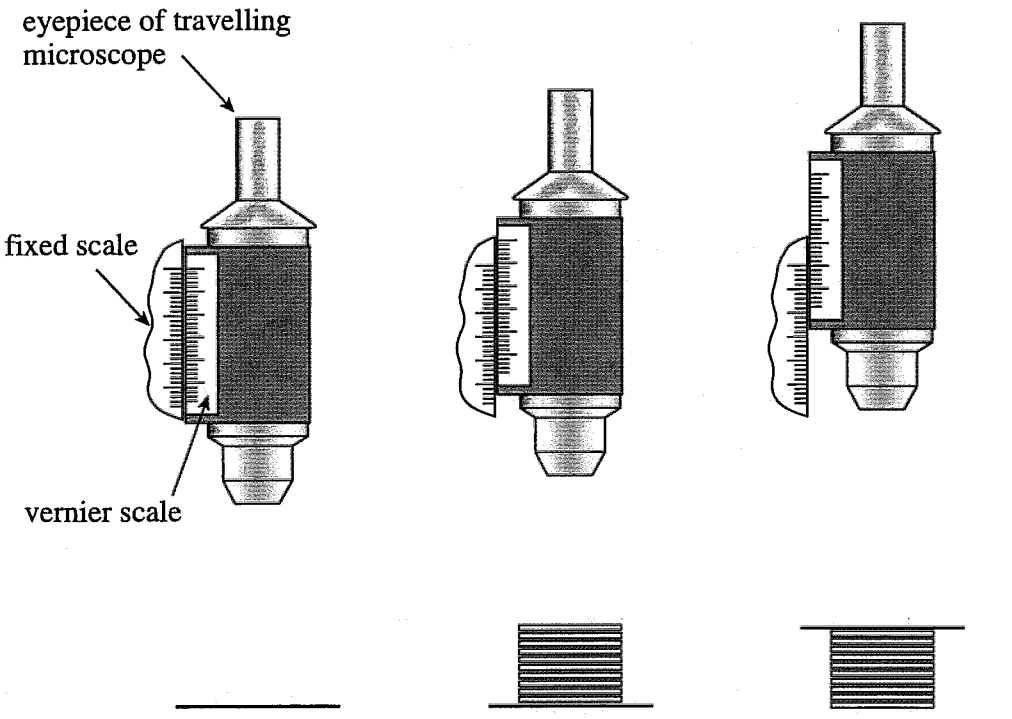
6

4 The student uses a travelling microscope to learn more about the properties of the glass slides.

The eyepiece of the microscope is arranged to move vertically up or down above a scrap of newspaper showing a photograph.
The photograph is composed of dots which are only clearly visible when viewed through the microscope. By adjusting the position of the microscope the student brings the dots into focus and then reads the position of the microscope, R_0, using the vernier scale.
The student then places a stack of 12 slides over the photograph and refocuses the microscope. She records the new reading, R_1.
Finally, she places the photograph on top of the slides, refocuses the microscope, and records the new reading R_2.

The sequence of operations is illustrated in **Figure 6**.

Figure 6



The readings made by the student are shown in the table below.

R_0 / mm	R_1 / mm	R_2 / mm
2.74	**7.31**	**17.02**

4 (a) Assuming that the slides have identical dimensions, use the readings to determine the thickness of one glass microscope slide.

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(1 mark)

4 (b) Determine n, the refractive index of the glass, given by $n = \dfrac{R_2 - R_0}{R_2 - R_1}$.

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(1 mark)

4 (c) The uncertainty in each of the readings R_0, R_1 and R_2, is 0.04 mm.

4 (c) (i) State the uncertainty in $R_2 - R_0$.

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4 (c) (ii) State the uncertainty in $R_2 - R_1$.

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4 (c) (iii) Hence calculate the percentage uncertainty in n.

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(3 marks)

5

END OF SECTION B