THIS IS A NEW SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

PHYSICS B (ADVANCING PHYSICS) G491

Physics in Action

Candidates answer on the Question Paper

OCR Supplied Materials:
- Data, Formulae and Relationships Booklet

Other Materials Required:
- Electronic calculator
- Ruler (cm/mm)

Wednesday 13 January 2010
Morning

Duration: 1 hour

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You are advised to spend about 20 minutes on Section A and 40 minutes on Section B.
- The values of standard physical constants are given in the Data, Formulae and Relationships Booklet. Any additional data required are given in the appropriate question.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means, for example, you should
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **20** pages. Any blank pages are indicated.

Answer **all** the questions.

Section A

1 Here are equations for electrical resistivity and conductivity:

$$\rho = \frac{RA}{L} \qquad \sigma = \frac{GL}{A}$$

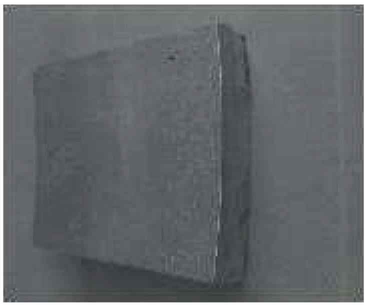
Write down correct units for

(a) electrical resistivity ....

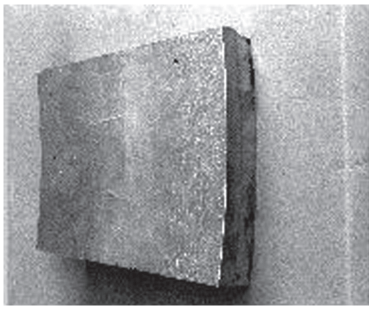
(b) electrical conductivity. ....

[2]

2 Fig. 2.1a shows an under-exposed image. Fig. 2.1b shows the image improved after processing. Below each image are histograms showing the number of pixels against the greyscale value 0 (black) and 255 (white) of each image.



under-exposed image



processed image

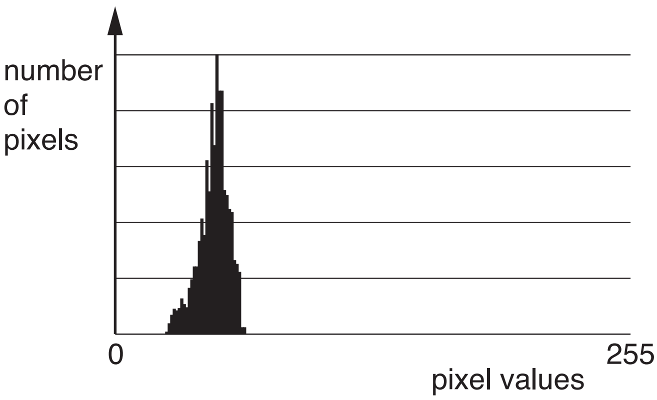


Fig. 2.1a

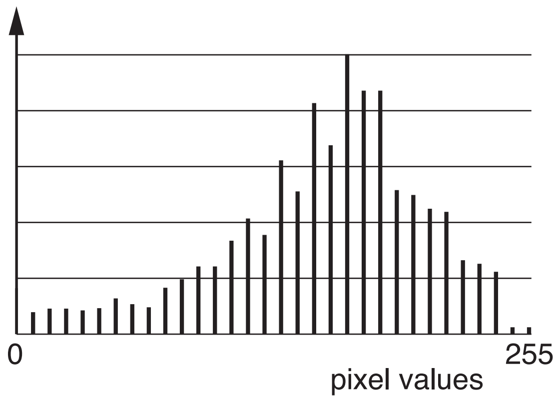
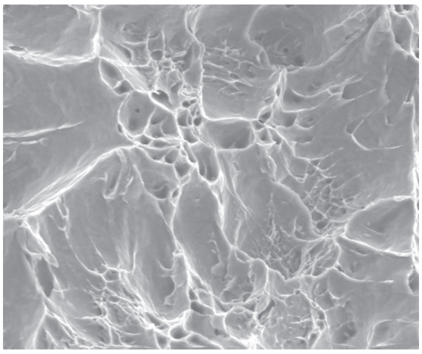


Fig. 2.1b

State one way in which the image has been modified to achieve this improvement.

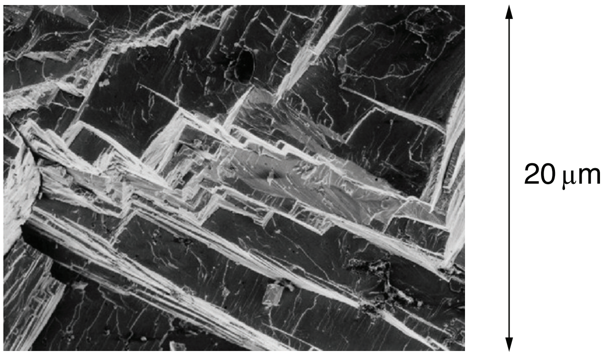
[2]

3 Fig. 3.1 shows electron microscope images of the fracture of the **same** material, mild steel.
Fig. 3.1a shows ductile fracture at room temperature.
Fig. 3.1b shows brittle fracture at the much lower temperature of –190°C.
Both images are on a scale of 20 μm.



room temperature

Fig. 3.1a



low temperature

Fig. 3.1b

Fig. 3.1

(a) Fig. 3.1a shows regions of plastic flow formed during the ductile fracture of the mild steel at room temperature.

State a feature from Fig. 3.1b that suggests mild steel undergoes brittle fracture at low temperature.

[1]

(b) Suggest a reason why mild steel is not a suitable material for the outer skin of an artificial satellite to operate in space.

[1]

4 Fig. 4.1 shows part of an analogue signal with some random noise.

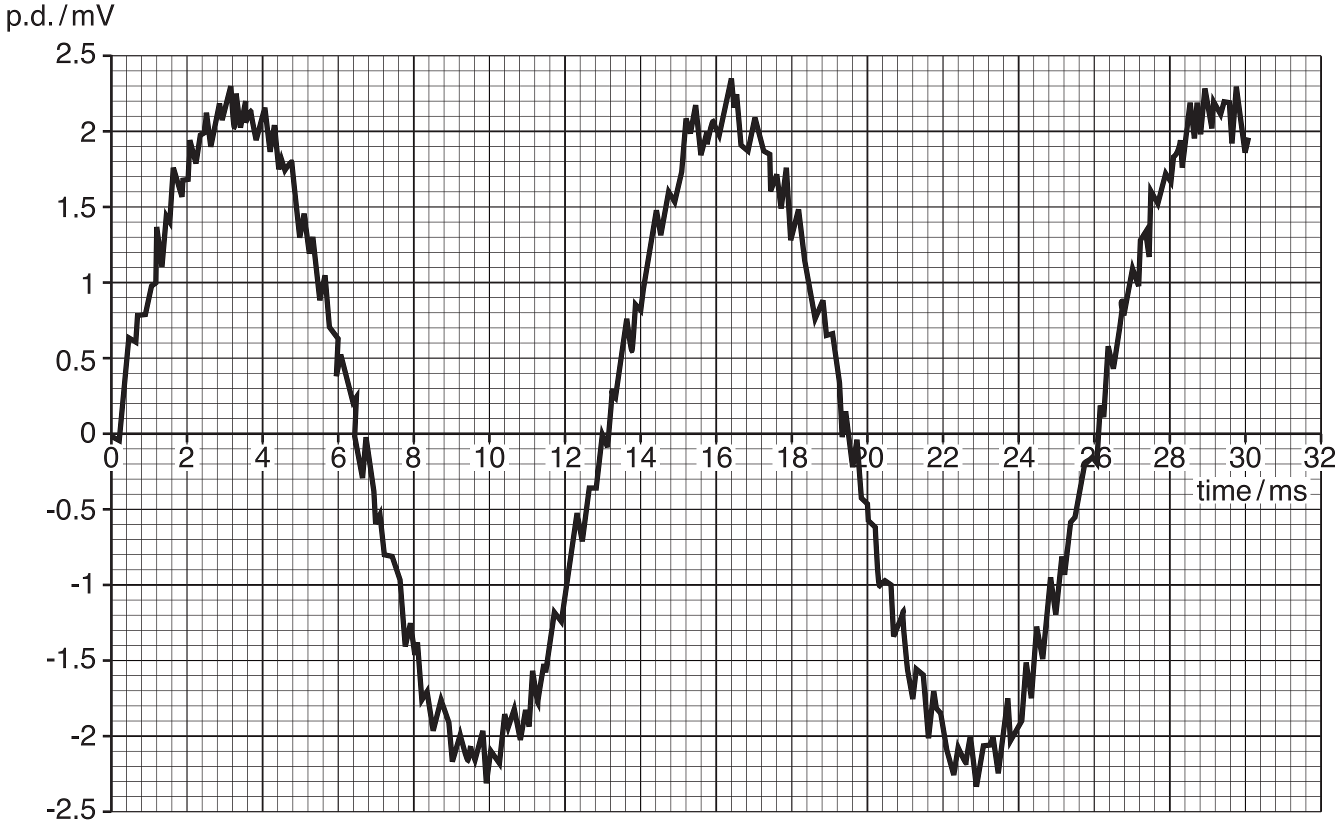


Fig. 4.1

(a) Estimate the peak to peak voltage of the **analogue signal.**

peak to peak voltage = ………….. mV **[1]**

(b) Estimate the peak to peak voltage variation of the **noise** in the signal.

peak to peak voltage variation = ………….. mV **[1]**

(c) The signal is sampled and digitised, using 8 bits per sample.

Calculate the number of sampling levels.

number of sampling levels = ………… **[1]**

(d) Suggest why it would be more appropriate to use 4 bits per sample for the digitisation of this noisy signal.

[2]

5 A mains kettle operates at 240 V and is rated at 2.2 kW.

Calculate the resistance of the kettle heating element when operating normally.

resistance = ……………….. Ω **[2]**

6 **(a)** Name two materials which together make a composite material.

………………………………………………… and …………………………………………………

make the composite material .... **[2]**

(b) State the useful properties that **each** material contributes to the composite.

[2]

7 Fig. 7.1 shows plane wavefronts (wavelength not to scale) from a point on a distant object approaching a converging lens in a digital camera.

Complete the diagram showing how the wavefronts after the lens are focused onto the CCD surface of the camera. The first wavefront has been drawn for you.

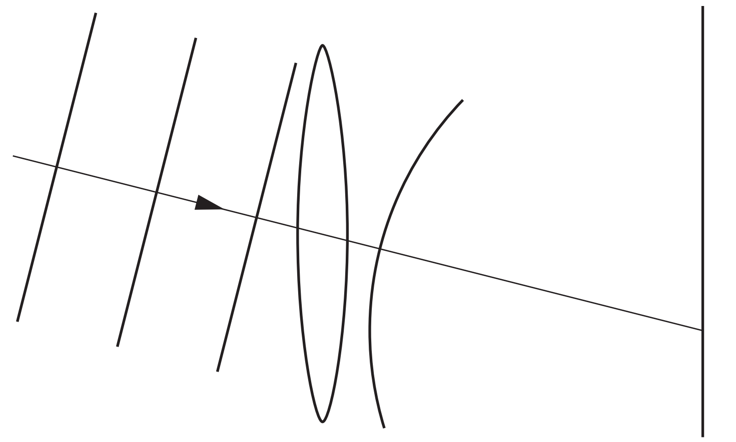


Fig. 7.1

[2]

[Total Section A:19]

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Section B

8 Fig. 8.1 shows part of the stress against strain graph for mild steel, up to a strain of 0.5%, obtained from a tensile testing machine.

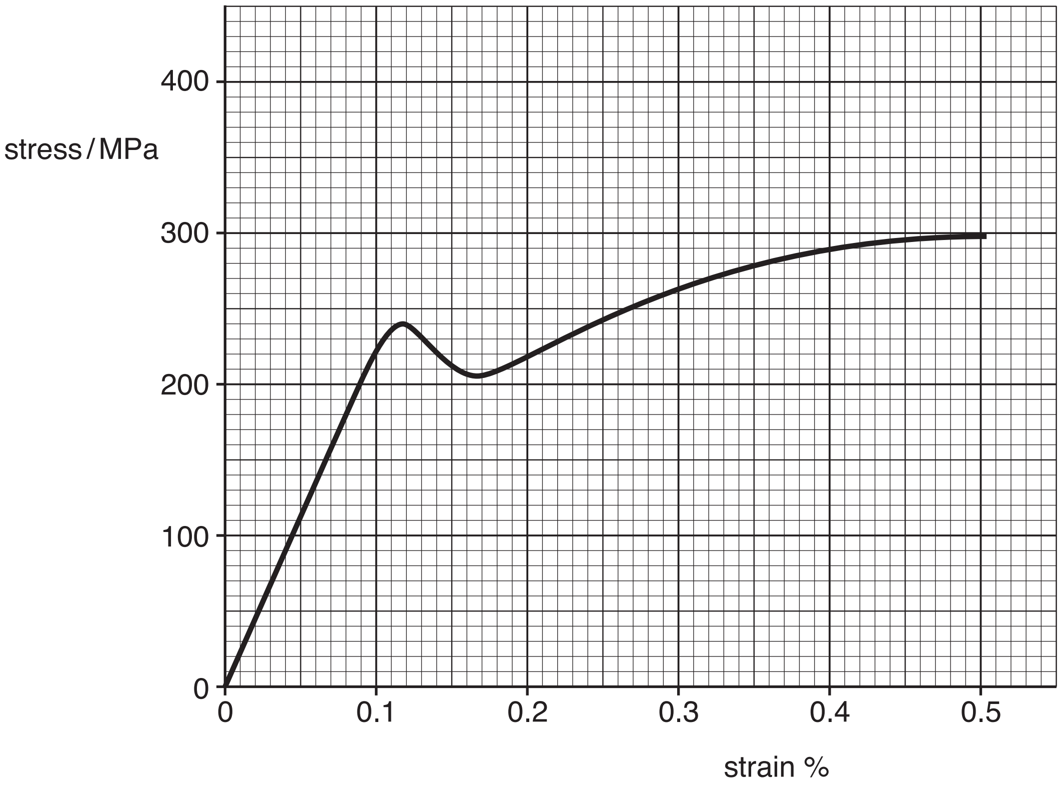

Fig. 8.1

(a) **(i)** Describe the behaviour of mild steel up to a strain of 0.1%.

[1]

(ii) Calculate the Young modulus for mild steel.
Make your method clear.

Young modulus = ………………...................... Pa **[3]**

(b) The sample of mild steel tested had a diameter D of 8.0 mm and original length L of 0.20 m.

(i) Calculate the extension of the specimen at the end of the test, when the strain is 0.5%.

extension = ……………….. m **[1]**

(ii) Calculate the maximum force applied by the tensile testing machine to the sample. Make your method clear.

maximum force = ………………… N **[3]**

(c) One student correctly states that plastic deformation must be occurring above a strain of about 0.11%.

A second student incorrectly argues that plastic flow cannot occur at such a low strain. He argues that if the stress is enough to make one plane of atoms slip, it must be enough to make **all** the planes slip together. He uses the following diagrams in Fig. 8.2 to illustrate his case.

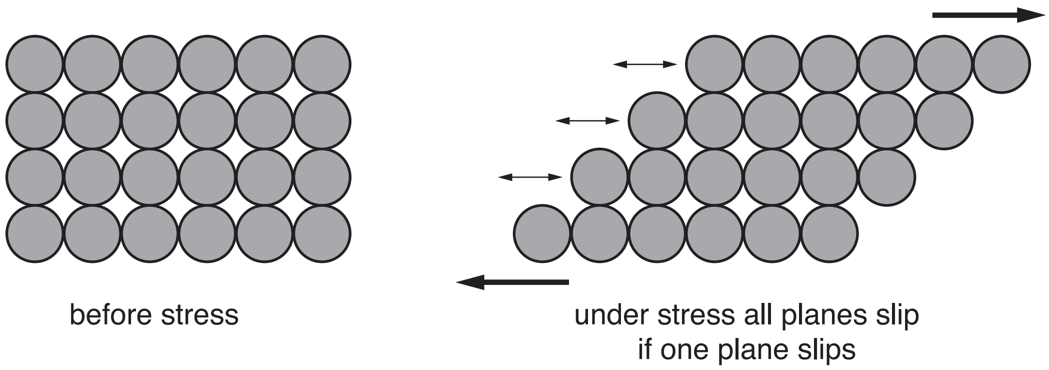

Fig. 8.2

Write an explanation for the second student to point out where his ideas are going wrong and why the first student is correct.

In your answer, you should make clear the changes in arrangement of atoms and how this accounts for the large scale behaviour of the metal.

[3]

[Total: 11]

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9 This question is about measuring the electrical conductivity of a semiconductor. The semiconductor is in the form of a square chip of side about 10 mm, and about 1 mm thick as shown in Fig. 9.1.

The resistance of the slice is of order of magnitude 100 Ω.
Current is passed into the shaded vertical end of the slice as shown.

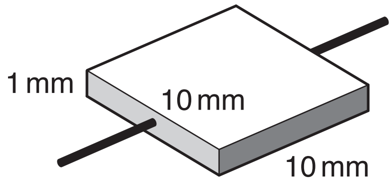

Fig. 9.1

(a) Draw a diagram of a circuit that could be used to obtain the electrical measurements required to determine the electrical conductivity of the semiconductor.

[2]

(b) Describe clearly how to obtain all the measurements needed to determine the conductivity.

[3]

(c) Describe how the data is used to calculate a value for the conductivity of the semiconductor.

[2]

(d) Suggest **one** way in which you could improve the measurement of the conductivity, by reducing uncertainty or systematic error in part of the measurement.

In your answer, you should clearly identify a source of uncertainty or systematic error, describe clearly the change you suggest, and explain how it would improve the measurement.

[3]

[Total: 10]

10 A HDTV (high definition television) image consists of 720×1280 colour pixels each coded by 24 bits of information. 50 separate images are displayed each second during transmission.

(a) **(i)** Show that the maximum rate of flow of information to the screen is greater than 10^9 bits per second.

[1]

(ii) Show that the maximum amount of information that might be required for transmission of **one hour** of HDTV in this system is nearly 500 **Gbytes**.

[2]

(iii) A digital TV recorder has a memory capacity of 200 Gbytes and can record up to 80 hours of HDTV programmes.

Show that the recorder is using less than 3 Gbytes of memory for storing each hour of recording.

[1]

(b) The carrier frequency of the electromagnetic waves for transmitting the HDTV signal is 850 MHz. The bandwidth of the signal is 10 MHz, between 845 and 855 MHz.

(i) Use the calculations in **(a)** to explain why data compression is needed for recording 80 hours of TV.

[1]

(ii) Use the calculations in **(a)** to explain why compression is needed for transmission with a bandwidth of 10 MHz.

[1]

(c) The carrier wave is vertically polarised.

Explain what is meant by *vertically polarised*. You may wish to use labelled diagrams in your answer.

[2]

[Total: 8]

11 Fig. 11.1 shows a pressure gauge. A pressure difference curves a thin metal plate **P**. Identical strain gauge resistors **F** and **B** are glued to the front and back of plate **P**. As plate **P** curves resistor **F** is compressed and resistor **B** is stretched.

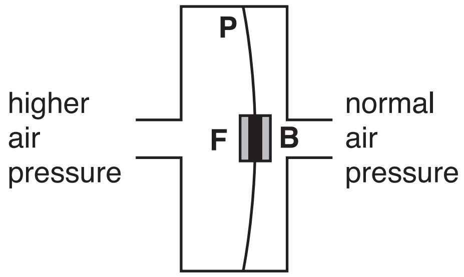

Fig. 11.1

(a) The strain gauge resistors are made of thin metal films of unstrained resistance 120 Ω. The resistors are connected in series across a 6.0 V supply of negligible internal resistance as shown in Fig. 11.2. The output p.d. of the circuit is measured across the stretched resistor **B**.

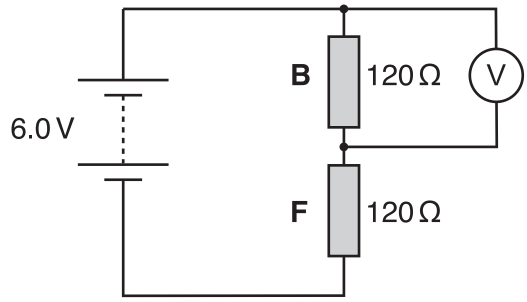

Fig. 11.2

(i) Calculate the current in the two series resistors when the plate **P** is flat.

current = ... A **[1]**

(ii) A pressure difference now curves plate **P** as shown in Fig. 11.1. When the plate **P** curves, the p.d. across resistor **B** increases, but the current calculated in **(i)** remains the same.

Explain how both these effects can occur.

[3]

(b) Fig. 11.3 shows the calibration graph for the pressure sensor.

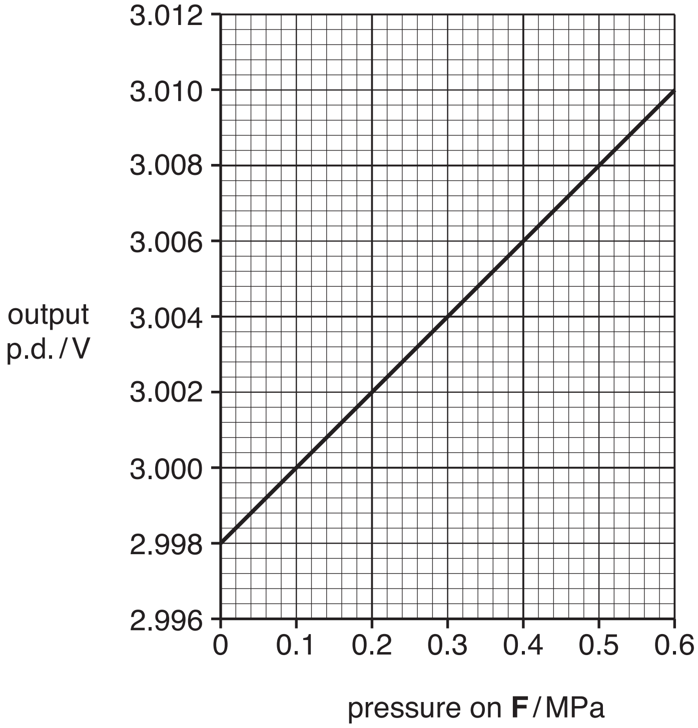

Fig. 11.3

(i) Use data from Fig. 11.3 to calculate the sensitivity of the pressure sensor.

sensitivity = …………… V MPa^{-1} **[2]**

(ii) A multimeter is used to measure the output p.d. of the circuit in Fig. 11.2. The meter can record the p.d. to the nearest 1 mV.

Calculate the pressure resolution of this pressure sensor.
Make your method clear.

resolution = ... Pa **[2]**

(iii) Explain how there can be a systematic error of pressure measurement if the two resistors are not at the same temperature.

[2]

(c) The resolution of the sensor can be improved using the modified circuit shown in Fig. 11.4.

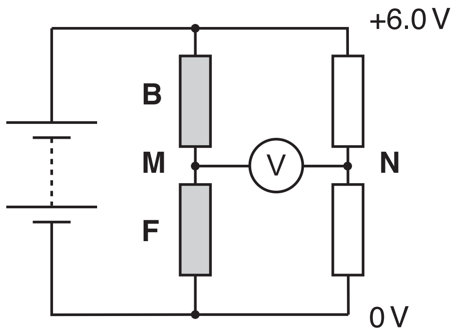

Fig. 11.4

A second pair of resistors, each having a fixed value of 120 Ω is added in parallel with **B** and **F**. The multimeter is now connected between points **M** and **N** as shown.

(i) All four resistors have the exact value 120 Ω when there is no pressure difference across plate **P**.

By considering the voltage at points **M** and **N**, explain why the p.d. across the input of the multimeter is zero when all four resistances are equal.

[1]

(ii) The multimeter can now be used on a more sensitive scale measuring to the nearest 0.01 mV.

State the improved resolution of the pressure sensor using the multimeter in this new arrangement.

pressure resolution = ………………. Pa **[1]**

[Total: 12]

[Total Section B: 41]

END OF QUESTION PAPER

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