Centre Number						Candidate Number				
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Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
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5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2011

Applied Science SC05

Unit 5 Choosing and Using Materials

Friday 20 May 2011 9.00 am to 10.30 am

For this paper you must have:
- a pencil
- a ruler
- a calculator.

Time allowed
- 1 hour 30 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show the working of your calculations.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.
- You are expected to use a calculator where appropriate.

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

1 A teacher sets up a demonstration to measure the weight and volume of a solid object that has an irregular shape.
The object is attached to a newton meter.
A 100 cm^3 measuring cylinder is partly filled with water.
The diagrams show the object in air, fully submerged in water and partly submerged in water.

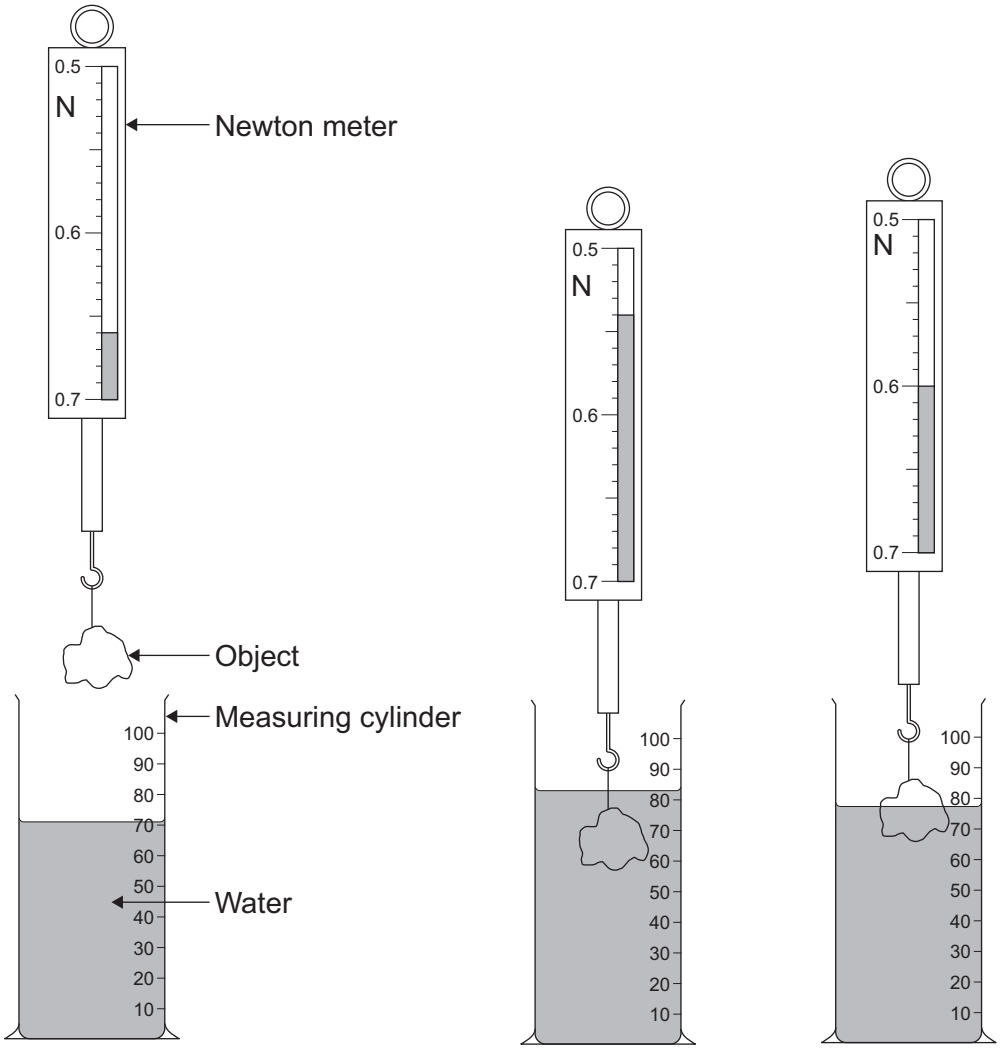


Diagram 1 **Diagram 2** **Diagram 3**

The table shows the readings taken from the newton meter and the measuring cylinder.

	Diagram 1	**Diagram 2**	**Diagram 3**
Weight in N	0.66	0.54	0.60
Volume in cm^3	71	83	77

1 (a) (i) From which diagram, **1**, **2** or **3**, would you take a reading to find the mass of the object?

.....

(1 mark)

1 (a) (ii) Explain your answer.

.....

.....

(1 mark)

1 (b) (i) From which **two** diagrams would you use readings to find the volume of the object?

Diagrams ..... and .....

(1 mark)

1 (b) (ii) Explain your answer.

.....

.....

(1 mark)

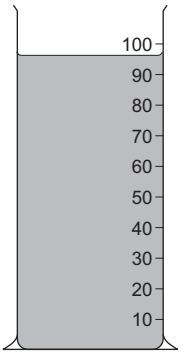
1 (b) (iii) What is the volume of the irregular shaped object?

.....

..... cm^3

(1 mark)

1 (b) (iv) The teacher gave a student the measuring cylinder shown below.



Explain why it would not be possible to use this measuring cylinder with the volume of water shown to find the volume of the object.

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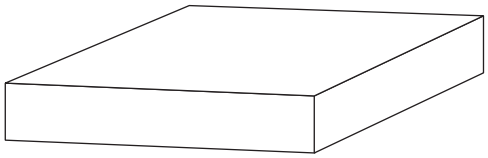
(2 marks)

Turn over ▸

1 (c) The diagram shows a solid metallic object with a regular shape.



1 (c) (i) Describe a different way of finding its volume other than the method described in part (b).

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(2 marks)

1 (c) (ii) The metallic object has a mass of 1.35 kg and a volume of $5 \times 10^{-4}\,m^3$.
Calculate the density of the metal. Give the correct unit in your answer.

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(3 marks)

12

Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

2 A manufacturer wanted to make some bookshelves for a set of heavy books. The table shows the tensile strength of four possible materials.

Material	**Tensile strength ($N\,m^{-2} \times 10^6$)**
Wood (oak)	85
Glass	60
Hardboard	40
Plywood	10

2 (a) (i) What is the meaning of *tensile strength*?

.....

.....

(1 mark)

2 (a) (ii) The tensile strength of the materials in the table are given in $N\,m^{-2}$ rather than a force measured in newtons (N). Explain why.

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(2 marks)

2 (b) Which of the materials in the table would be best for making bookshelves for a set of heavy books?

.....

(1 mark)

2 (c) (i) Plywood is a composite material.
What is meant by a *composite material*?

.....

.....

(1 mark)

2 (c) (ii) Give **one** benefit of using a composite material.

.....

.....

(1 mark)

2 (c) (iii) Which of the following types of composite material is plywood?
Tick the box next to the correct answer.

Fibre ☐ Laminate ☐ Particle ☐ *(1 mark)*

2 (d) Glass, hardboard and plywood are synthetic materials.
What is meant by a *synthetic material*?

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(1 mark)

2 (e) Glass is an amorphous material.
What is meant by *amorphous*?

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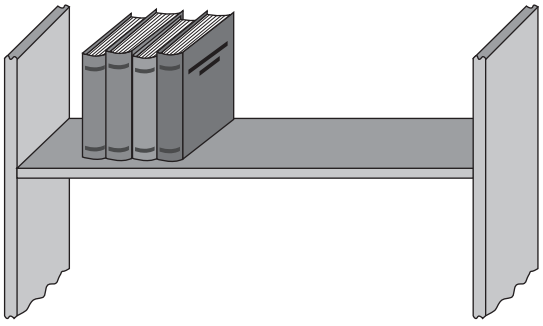
(1 mark)

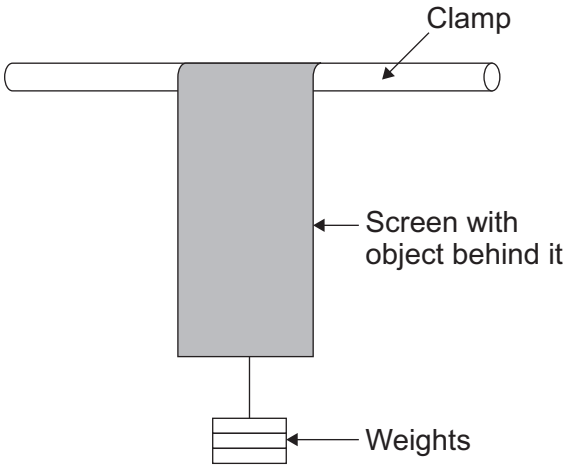
2 (f) The diagram shows a shelf supporting a set of books.



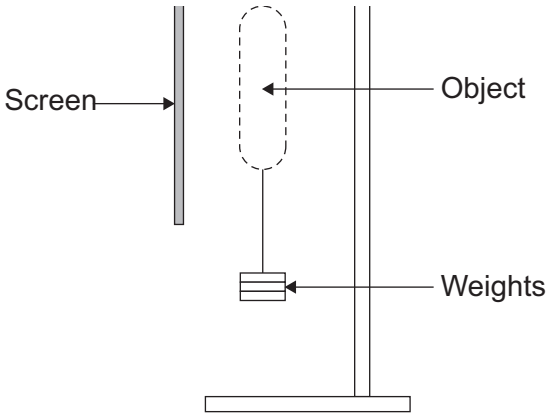
Draw an arrow pointing to a part of the shelf which is under tension. *(1 mark)*

10

3 A teacher suspends an object from a clamp. She puts a small screen in front of the object so that the students cannot see it.



Front view

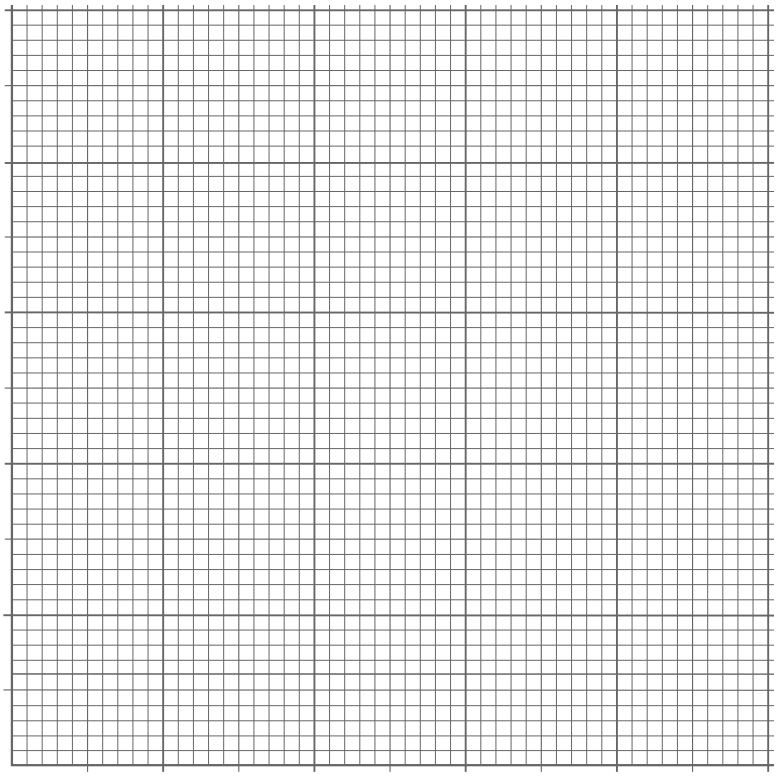


Side view

3 (a) Different weights are attached to the bottom of the object to exert different forces on it. In each case the extension of the object is measured.
The table shows the results.

Extension (cm)	0.0	1.1	1.8	2.6	3.3
Applied force (N)	0.0	3.0	5.0	7.0	9.0

Plot the data in the table on the grid provided.
Put the applied force on the *x*-axis and the extension on the *y*-axis.
Label the axes, add appropriate units and draw a line of best fit.



(4 marks)

3 (b) (i) Using your graph on **page 8**, describe how the extension varies as the applied force is increased.

.....

.....

.....

(2 marks)

3 (b) (ii) Use your graph on **page 8** to find the extension for an applied force of 8.0 N.

.....

(1 mark)

3 (b) (iii) Explain why the extension for an applied force of 800 N is unlikely to be one hundred times the value in part (b)(ii).

.....

.....

(1 mark)

3 (c) The teacher tells her students that the object is one of three things:

- a metal spring
- a metal wire
- a length of string.

3 (c) (i) Which **one** is it most likely to be?

.....

(1 mark)

3 (c) (ii) Give **two** reasons for your choice.

Reason 1 .....

.....

Reason 2 .....

.....

(2 marks)

11

Turn over ▸

4 **Read this article about ceramics and use the information and your own knowledge to answer the questions that follow.**

Ceramics

Pottery is the best known example of a ceramic material. The production of clay pots is one of the oldest forms of materials technology. The ceramic tiles used on the space shuttle are an example of modern materials technology.

Ceramic materials are crystalline compounds. The bonds in ceramics are mainly covalent, but some are ionic. The bonds are directed in space, and the structure of a ceramic is therefore more rigid than a metallic structure. This structure makes ceramic materials:

- strong in compression and weak in tension
- very hard-wearing
- brittle
- poor thermal and electrical conductors
- chemically unreactive
- heat resistant.

The resistance of ceramics to heat and corrosion gives them many uses. They are used in making spacecraft, cutting tools, engine parts, turbine blades, electronic components and artificial bones.

Traditionally, alloys and polymers have been used in medicine for replacement body parts, for example hips and knees. Recently, ceramics have been considered as implant materials. Ceramics have a high strength-to-weight ratio, wear better than alloys or polymers and never corrode. Porous ceramic implants can be used for replacing damaged bone, so that new bone can grow into and bond with the implant.

Glass is similar to ceramic materials. One of the main differences between the two is that glass is generally transparent but most ceramics are opaque. Ceramics are opaque because light is reflected back by grain boundaries in the crystal structure.

4 (a) Give **one** property of ceramics, listed in the article, that makes them suitable for making the lining of furnaces.

.....

.....

(1 mark)

4 (b) Give **one** property of ceramics, listed in the article, that makes them suitable for use in kitchens.

.....

.....

(1 mark)

4 (c) Give the meaning of the following terms used in the article.

covalent bond .....

.....

ionic bond .....

.....

strong in compression .....

.....

brittle .....

.....

(4 marks)

4 (d) Suggest a reason why ceramics do not conduct electricity.

.....

.....

(1 mark)

4 (e) (i) Ceramics are described as having a high strength-to-weight ratio.

Explain the meaning of the term *strength-to-weight ratio*.

.....

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(1 mark)

4 (e) (ii) Why is it an advantage for a material to have a high strength-to-weight ratio?

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(1 mark)

4 (f) Suggest a reason why glass is transparent.

.....

.....

(1 mark)

10

5 Metals and polymers are useful groups of materials.

5 (a) (i) Aluminium is used in making the overhead electricity cables used in the National Grid.

Give **two** properties of aluminium that make it suitable for this use.

Property 1 .....

.....

Property 2 .....

.....

(2 marks)

5 (a) (ii) The aluminium electricity cables are supported by steel pylons.
Apart from cost, suggest why pylons are made from steel rather than aluminium.

.....

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(1 mark)

5 (a) (iii) Steel is an alloy.
What is meant by *alloy*?

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(1 mark)

5 (b) What is a *polymer*?

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(1 mark)

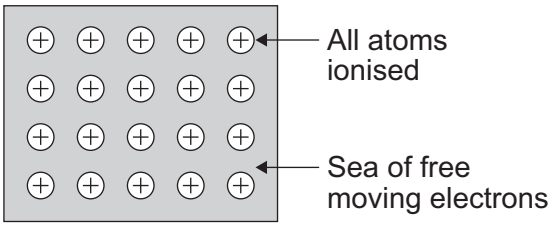
5 (c) The properties of a polymer depend on its structure.
Materials scientists need to know how differences in the structure of polymers affect their properties.

In the table, write either 'increase', 'decrease' or 'no change' in the boxes to show the effect of each of the differences in structure on the properties of polymers.

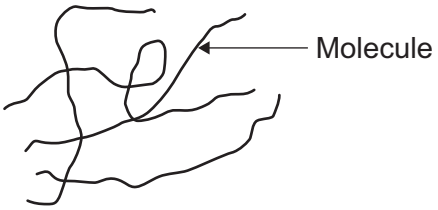
Structure	Effect on melting point	Effect on strength	Effect on electrical conductivity
Increase the length of the polymer molecule			
Introduce side chains to the polymer molecule			
Introduce cross-linking between the polymer molecules			

(6 marks)

5 (d) The diagrams **A**, **B**, **C** and **D**, show the internal structures of different materials.



A



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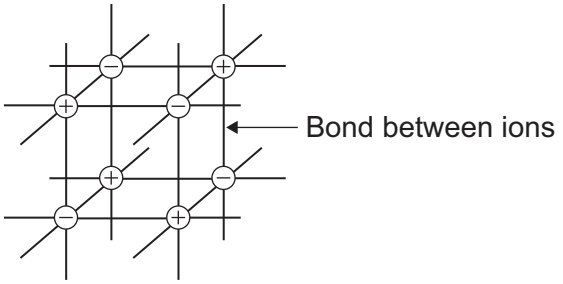
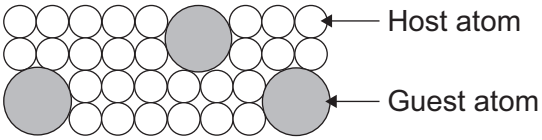


C



D

5 (d) Tick the box to show which diagram **A**, **B**, **C** or **D** best represents the internal structure of each of the following

	A	B	C	D
A pure metal, like aluminium	☐	☐	☐	☐
An alloy, like steel	☐	☐	☐	☐
A polymer	☐	☐	☐	☐

(3 marks)

14

Turn over ▶

6 A crane manufacturer is deciding which type of steel cable to use. The cable needs to have the correct stiffness. It must be made from a ductile material, but must be strong enough to support the load without stretching too much or breaking.

6 (a) (i) Define *stiffness* .....

.....

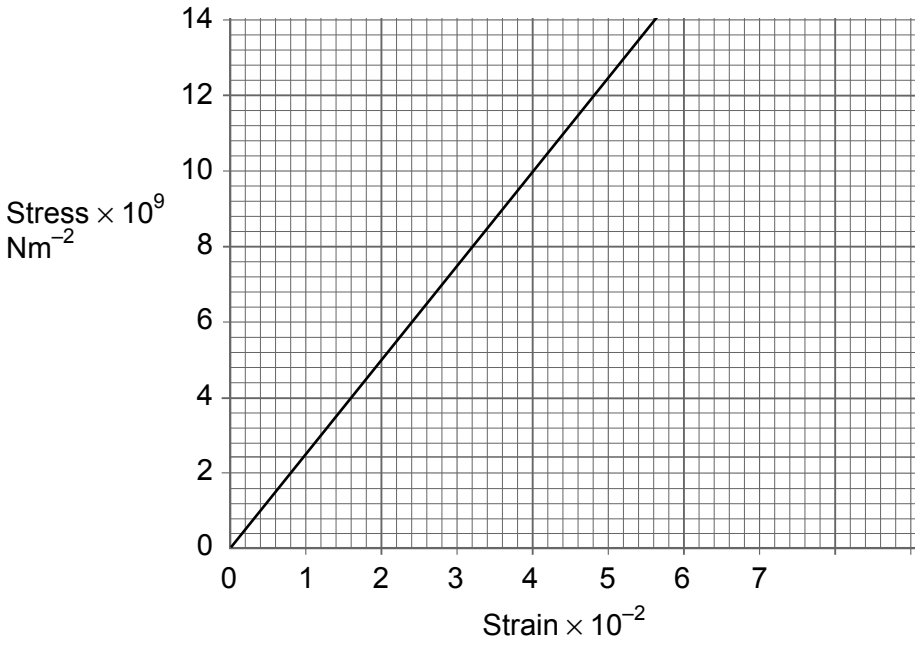
(1 mark)

6 (a) (ii) Define *ductile* .....

.....

(1 mark)

6 (b) The manufacturer of a cable has supplied some information about its stress-strain characteristics. The graph shows this information.



6 (b) (i) What is the definition of *stress*?

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(1 mark)

6 (b) (ii) What is the definition of *strain*?

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(1 mark)

6 (b) (iii) Why are there no units for strain?

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(1 mark)

6 (c) The steel cable used to produce the graph has a cross-sectional area of $4.5 \times 10^{-3}\,m^2$.

6 (c) (i) Calculate the force applied to the cable when the strain is 4×10^{-2}.

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..... N

(3 marks)

6 (c) (ii) Calculate the Young modulus of the steel. Give the correct unit in your answer.

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(3 marks)

6 (d) Apart from stiffness and ductility, give **one** other physical property that the crane manufacturer should consider when choosing a cable.

.....

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(1 mark)

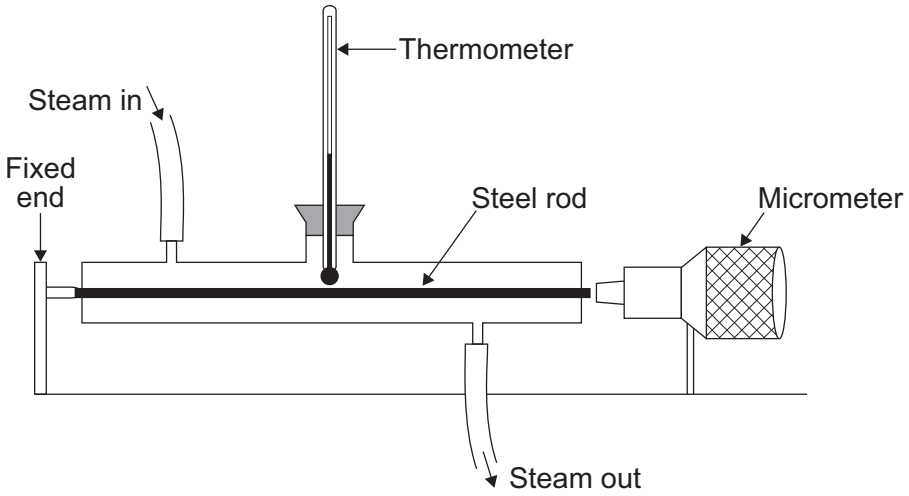
12

7 Substances expand when they are heated. Engineers need to allow for expansion when building bridges and roads.

The expansion of different substances can be compared by looking at their coefficients of linear expansion.
The coefficient of linear expansion can be calculated using the formula:

$$\text{coefficient of linear expansion} = \frac{\text{expansion}}{\text{original length} \times \text{rise in temperature}}$$

The diagram shows apparatus which can be used to determine the coefficient of linear expansion of steel.



7 (a) Describe how you would use this apparatus to obtain a value for the coefficient of linear expansion of steel.

You should include the measurements that need to be made and the instruments you would use to make these measurements.

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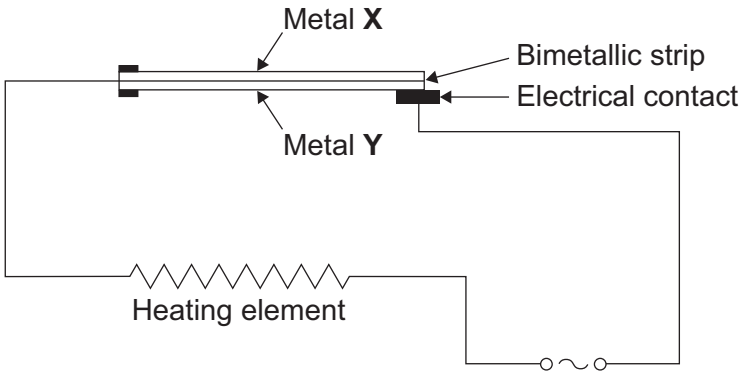
(8 marks)

Question 7 continues on the next page

7 (b) The diagram below shows a bimetallic strip being used in a thermostat. The strip bends upwards as the temperature increases.



The coefficients of linear expansion of four metals are:

Iron	$1.3 \times 10^{-5}\,°C^{-1}$	Platinum	$9.0 \times 10^{-6}\,°C^{-1}$
Copper	$1.7 \times 10^{-5}\,°C^{-1}$	Aluminium	$2.6 \times 10^{-5}\,°C^{-1}$

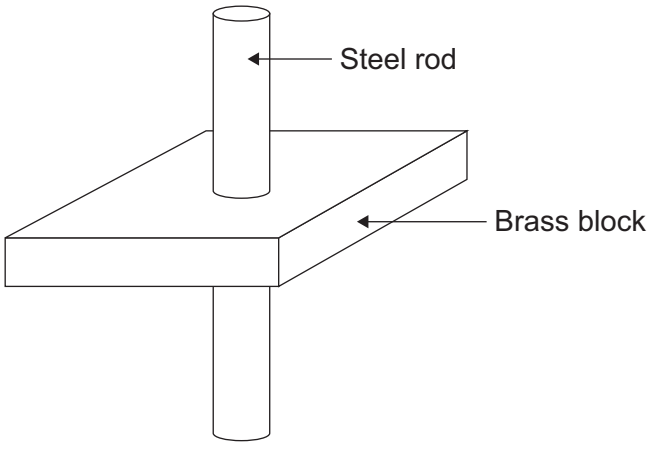
The thermostat must be as sensitive as possible. Which of these metals should be used for **X** and **Y**?

X ..... **Y** .....

(2 marks)

7 (c) The diagram below shows a steel rod which has become firmly stuck inside a hole drilled in a brass block.

When both the steel and brass are heated, the steel rod is easily removed.
What does this indicate about the coefficients of linear expansion of steel and brass?



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(1 mark)

END OF QUESTIONS

11

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