Centre Number						Candidate Number				
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Other Names										
Candidate Signature										

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

General Certificate of Education
Advanced Subsidiary Examination
June 2015

Applied Science SC05

Unit 5 Choosing and Using Materials

Tuesday 12 May 2015 1.30 pm to 3.00 pm

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

Time allowed
- 1 hour 30 minutes

A

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 The building industry uses a wide variety of materials.
The uses of a material depend on its physical properties.

1 (a) (i) **Table 1** gives some examples of how different materials are used in the building industry. It also shows which class of materials some of the examples belong to.

Complete **Table 1** by adding the class of material most likely to be used for the other two examples shown.

[2 marks]

Table 1

Example of material and its use	Class of material
Polyethene gutters	Polymer
Steel-reinforced concrete for foundations	
Copper hot-water cylinder	Metal
Porcelain bathroom tiles	

1 (a) (ii) Some physical properties of two of the materials in **Table 1** are given in **Table 2**.

Table 2

Material	Melting point (°C)	Density (kg m^{-3})	Electrical conductivity	Thermal conductivity
A	1083	8920	Very good	Very good
B	110 to 140	950	Poor	Poor

For each material in **Table 2** name the class of material to which that material belongs, and select the property in **Table 2** that makes it suitable for the use given in **Table 1**.

[4 marks]

Material **A**

Class of material .....

Property .....

Material **B**

Class of material .....

Property .....

1 (b) Wood is a material that has traditionally been used to make window frames. These days, more modern materials are often used instead of wood.

1 (b) (i) Name a modern material used to make window frames.

[1 mark]

.....

1 (b) (ii) Give **two** advantages of making a window frame from the modern material you selected in part (b)(i).

[2 marks]

1.....

.....

2.....

.....

1 (c) What word is used to describe a material that is man-made?

[1 mark]

.....

10

Turn over for the next question

2 When selecting materials for particular purposes, mechanical engineers need to consider the properties of the materials.

2 (a) Explain what is meant by each of the following terms.

[2 marks]

Elastic limit .....

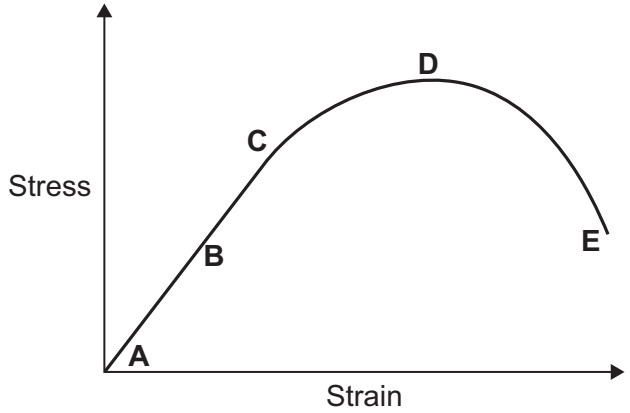
.....

Ultimate tensile strength .....

.....

2 (b) **Figure 1** shows how stress varies with strain for a given material.

Figure 1



2 (b) (i) Between which pair of letters in **Figure 1** is the material behaving **only** elastically? Tick **one** box.

[1 mark]

A and **B** ☐ **A** and **D** ☐

B and **D** ☐ **C** and **E** ☐

2 (b) (ii) Between which pair of letters in **Figure 1** is the material showing **only** plastic behaviour?

Tick **one** box.

[1 mark]

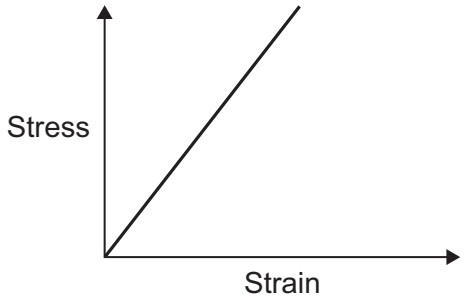
A and **B** ☐ **A** and **D** ☐

B and **D** ☐ **C** and **E** ☐

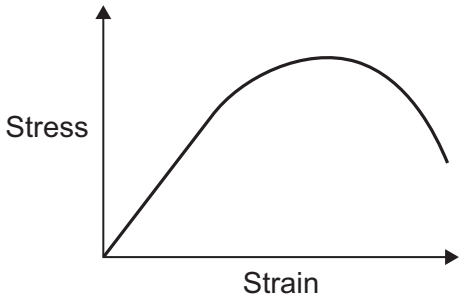
2 (c) The graphs in **Figure 2** show the behaviour of brittle and ductile materials.

Figure 2

Brittle material



Ductile material



Describe what the graphs in **Figure 2** show about the behaviour of brittle and ductile materials.

[2 marks]

Brittle material .....

.....

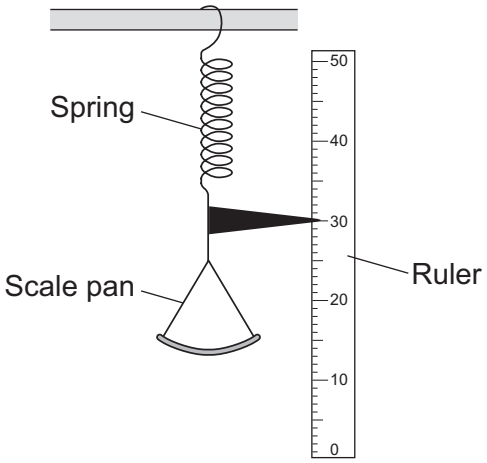
Ductile material .....

.....

Question 2 continues on the next page

2 (d) **Figure 3** shows a spring fitted with a scale pan that is suspended next to a ruler.

Figure 3



The spring obeys Hooke's law.

- When the pan is empty, the pointer is level with the 30 cm mark.
- When some sand is poured into the pan, the pointer points to the 15 cm mark.
- When a 20 g mass is put on top of the sand, the pointer points to the 5 cm mark.

2 (d) (i) What extension is produced by the sand?

[1 mark]

.....

2 (d) (ii) What extension is produced by the 20 g mass?

[1 mark]

.....

2 (d) (iii) What is the mass of the sand that is poured into the pan?

[1 mark]

.....

2 (d) (iv) Name the type of force acting on the stretched spring.

[1 mark]

.....

10

3 **Read the following article about tennis racquets.**
Use the information in the article and your own knowledge to answer the questions that follow.

Tennis Racquets

Tennis racquets used to be made of wood and were quite heavy, about 380 g. Wooden tennis racquets warped, cracked and dried out with age and they broke quite easily.

Later, aluminium was used to make tennis racquets. Aluminium was stronger, lighter and more flexible than wood. The head of an aluminium tennis racquet was more than 50% larger than that of a wooden racquet. The lighter weight and greatly increased power of these larger racquets was good for beginners. However, for powerful, advanced players the greater flexibility of the frames distorted the strings and the direction of the ball was unpredictable.

Good players needed a less flexible material for the frame. The best material proved to be a carbon fibre composite. This new material became known as 'graphite'. The technology for reducing flexibility without adding weight continues to advance. Today the average graphite tennis racquet weighs about 300 g. Tennis racquets made of graphite can last for many years.

3 (a) (i) Describe how the flexibility of tennis racquets has changed over the years.

[2 marks]

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.....

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3 (a) (ii) Suggest **one** advantage to tennis players of the larger head size of an aluminium racquet compared with a wooden one.

[1 mark]

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.....

3 (a) (iii) Give the meaning of the word **composite**.

[1 mark]

.....

.....

Question 3 continues on the next page

3 (a) (iv) What are the advantages to tennis players of using the modern graphite racquet?

[3 marks]

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3 (b) The strings of a tennis racquet can be made from nylon that has been through the process of cold drawing.

3 (b) (i) What is meant by **cold drawing**?

[2 marks]

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3 (b) (ii) What happens to the nylon polymer chains during cold drawing?

[1 mark]

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3 (b) (iii) How does cold drawing make nylon more suitable for use in tennis racquet strings?

[1 mark]

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11

4 The physical properties of a material depend on the structure of the material and the type of bonding between its particles.

The three types of strong bonding between particles are ionic, covalent and metallic.

4 (a) **Table 3** shows some general statements about ionic compounds and simple covalent compounds.

Tick **one** box in each row of **Table 3** to show whether each statement is only true for ionic compounds or only true for simple covalent compounds or true for both.

[3 marks]

Table 3

	Only true for ionic compounds	**Only true for simple covalent compounds**	**True for both**
Have very high melting and boiling points			
May have weak forces of attraction between molecules			
May have melting and boiling points below room temperature			
Do not conduct electricity in the solid state			
Atoms share electrons			

4 (b) Sodium chloride is an ionic compound. Sodium chloride dissolves in water.

What happens as sodium chloride dissolves in water?

Tick **one** box in each row of **Table 4** to complete each sentence.

[2 marks]

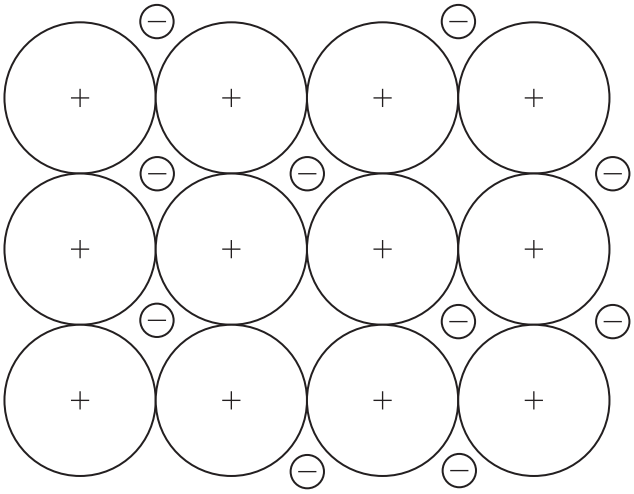
Table 4

	increases	**decreases**	**stays the same**
The movement of the ions...			
The charge on each ion...			
The total number of ions...			
The distance between the ions...			

Question 4 continues on the next page

4 (c) **Figure 4** shows a model of metallic bonding.

Figure 4



4 (c) (i) Name the **two** types of particle shown in **Figure 4**.

[2 marks]

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4 (c) (ii) Use **Figure 4** to explain why metals have good electrical conductivity.

[2 marks]

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4 (d) Describe the difference in structure between an amorphous material and a crystalline material.

[2 marks]

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11

5 Pure metals such as copper and tin are quite soft and malleable.
Bronze is a mixture of copper and tin. Bronze is stronger and less malleable than pure copper.

5 (a) What is meant by the term **malleable**?

[1 mark]

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5 (b) What is the name given to materials such as bronze?

[1 mark]

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5 (c) Explain why bronze is less malleable than pure copper. You may use diagrams to help your answer.

[3 marks]

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Question 5 continues on the next page

5 (d) Copper can be mixed with other metals to increase its hardness.
Name **two** other processes by which copper can be treated to increase its hardness.
[2 marks]

1 .....

2 .....

5 (e) A sample of bronze has a mass of 60 g and contains 86% copper (by mass) and 14% tin (by mass).

5 (e) (i) Calculate the mass of copper in the sample of bronze.
[1 mark]

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Mass = ... g

5 (e) (ii) The sample of bronze has a density of 8650 kg m^{-3}.

Calculate the volume of the bronze sample. Give the correct unit in your answer.
[3 marks]

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Volume = ...

5 (f) The density of bronze depends on the percentage of copper it contains.
This is shown in **Table 5**.

Table 5

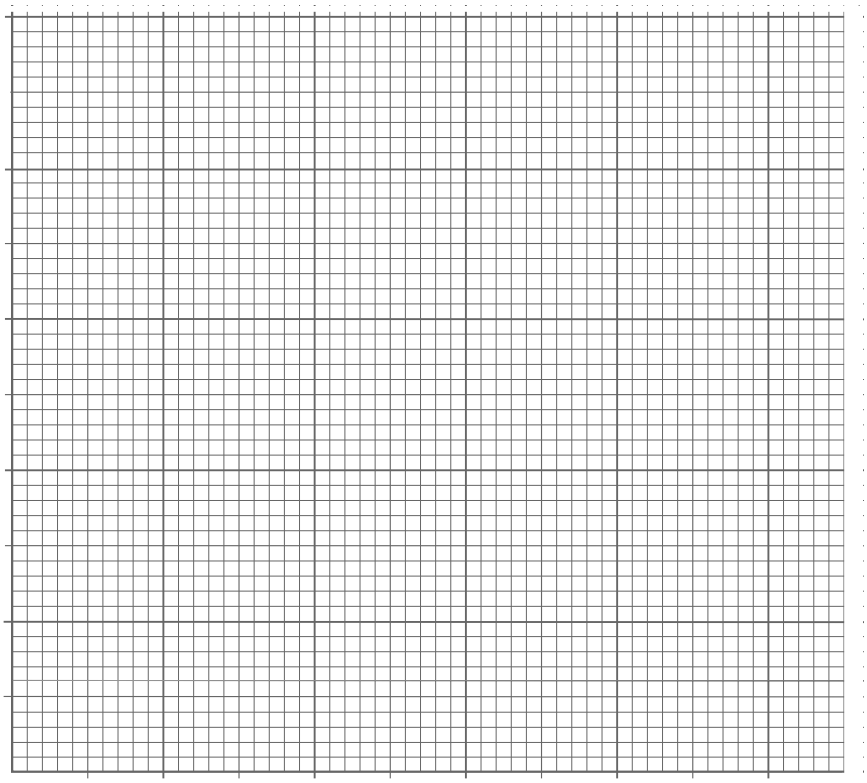
Percentage of copper	10	20	50	60	90
Density of bronze (kg $m^{-3} \times 10^3$)	7.3	7.5	8.0	8.2	8.7

5 (f) (i) Plot the data in **Table 5** onto the grid in **Figure 5**.

- Plot percentage of copper on the *x*-axis and density of bronze on the *y*-axis.
- Label the axes, add appropriate units and draw a line of best fit.

[3 marks]

Figure 5



5 (f) (ii) Use your graph to determine the value for the density of pure copper.

[1 mark]

Density = ... kg m^{-3}

5 (g) Bronze is used to make ships' propellers because of its high resistance to salt water corrosion compared with other materials such as steel and brass.

State **three** factors that should be kept constant when doing tests to compare how bronze, steel and brass are affected by salt water.

[2 marks]

1 .....

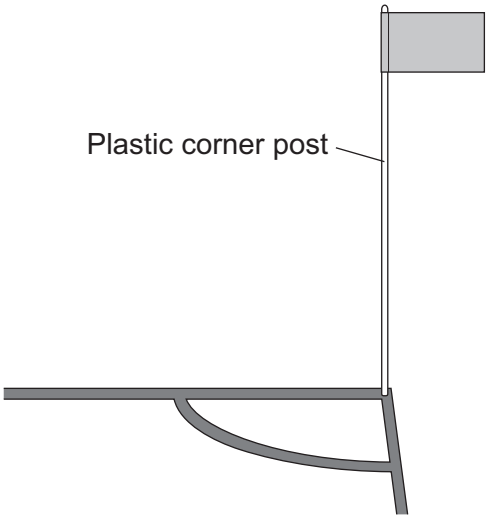
2 .....

3 .....

17

6 A company manufactures plastic corner posts for football pitches, as shown in **Figure 6**.

Figure 6



A technician at the company tests the flexibility of two different samples of plastic that could be used to make the corner posts.

Describe, with the help of a labelled diagram of the apparatus, how this could be done using equipment that would be available in a normal school laboratory.

[8 marks]

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Extra space (if needed) .....

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8

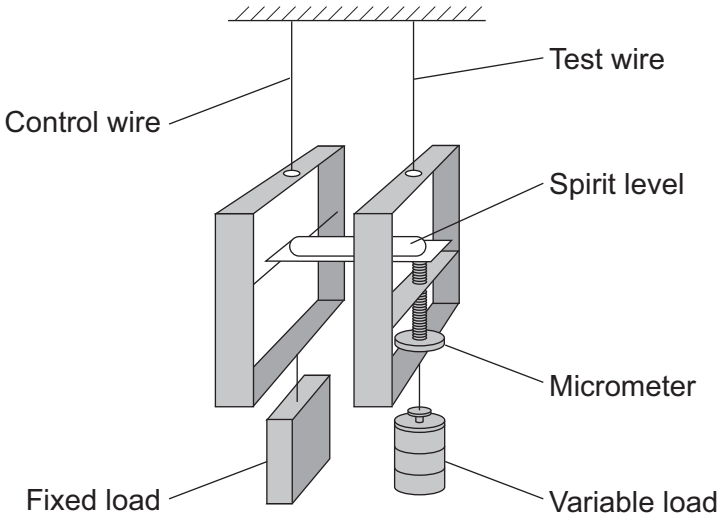
Turn over for the next question

7 The Young modulus is a measure of the stiffness of a material.

Searle's apparatus can be used to measure the Young modulus of a material in the form of a wire.

Figure 7 shows Searle's apparatus.

Figure 7



Searle's apparatus is used as follows.

- The micrometer is adjusted until the spirit level shows that the apparatus is level.
- The micrometer reading is noted.
- The original length of the test wire is measured with a ruler.
- The diameter of the test wire is measured.
- A weight is added to the variable load.
- The micrometer is readjusted to make the spirit level show level again.
- The new micrometer reading is noted.

7 (a) (i) What is the purpose of the **fixed** load?

[1 mark]

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7 (a) (ii) What is the purpose of the **variable** load?

[1 mark]

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7 (a) (iii) What is calculated using the diameter of the test wire?

[1 mark]

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7 (a) (iv) What measurement of the test wire is obtained by finding the difference between the micrometer readings?

[1 mark]

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7 (a) (v) How is the strain on the test wire calculated?

[1 mark]

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7 (a) (vi) How is the stress on the test wire calculated?

[1 mark]

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7 (a) (vii) How is the Young modulus calculated?

[1 mark]

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Question 7 continues on the next page

7 (b) A metal wire of length 1.2 m is clamped vertically. A weight is hung from the lower end of the wire.
The extension of the wire is 0.35 mm.
The cross-sectional area of the wire is 1.4×10^{-7} m^2.
The Young modulus of the metal is 1.9×10^{11} N m^{-2}.

7 (b) (i) Calculate the strain on the wire.

[2 marks]

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.....

Strain = ...

7 (b) (ii) Calculate the force on the wire.

[4 marks]

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Force = ... N

13

END OF QUESTIONS

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