Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
January 2011

Applied Science SC05

Unit 5 Choosing and Using Materials

Tuesday 11 January 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 When choosing a material for a product, materials scientists must consider the properties of the available materials.
Some properties of a material are useful, others are not.

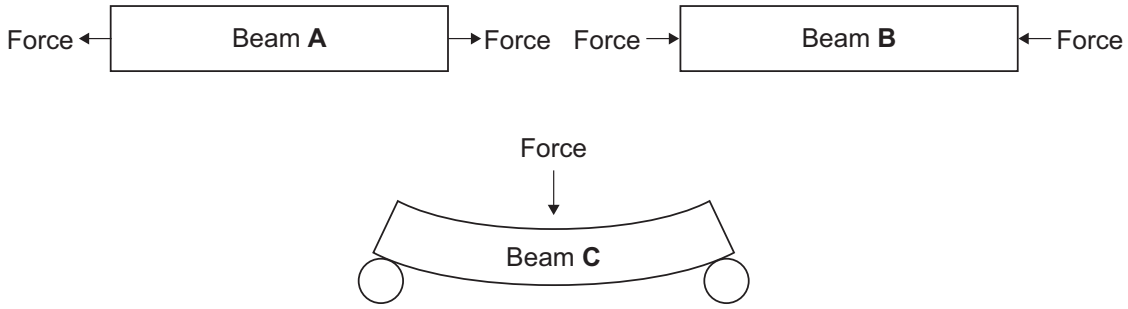
For each type of material draw **one** line to a box showing its useful properties and a second line to a box showing its non-useful properties.

Useful properties	**Type of material**	**Non-useful properties**
Often flexible Poor conductors of heat and electricity Low density	Metals	Brittle
High tensile strength Malleable and ductile Good conductors of heat and electricity	Polymers	Some corrode Some are very expensive
Chemically resistant Hardwearing Waterproof Insulators of heat and electricity	Ceramics	Most are non-biodegradable Soft and easily scratched Some produce toxic fumes when burnt

(6 marks)

6

2 The diagrams show three beams, **A**, **B** and **C**, with forces acting on them.



Tick the correct box next to each of the following to show

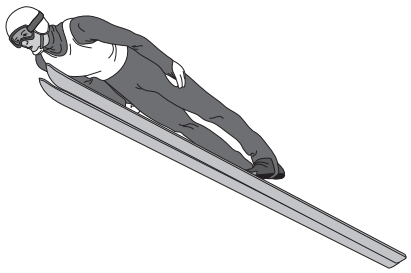
	A	**B**	**C**
which beam is in compression	☐	☐	☐
which beam is in tension	☐	☐	☐
which beam is in both compression and tension	☐	☐	☐

(3 marks)

3

Turn over for the next question

3 (a) The picture shows a ski-jumper in mid-air.



3 (a) (i) Suggest **one** way in which the ski-jumper's equipment is designed to produce the maximum possible speed through the air.

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.....

(1 mark)

3 (a) (ii) Below is a list of properties of materials. Select **one** that is desirable and **one** that is undesirable for the material from which the skis are made.
Explain your choices.

Elastic **Tough** **Plastic** **Brittle**

Desirable property .....

Reason .....

.....

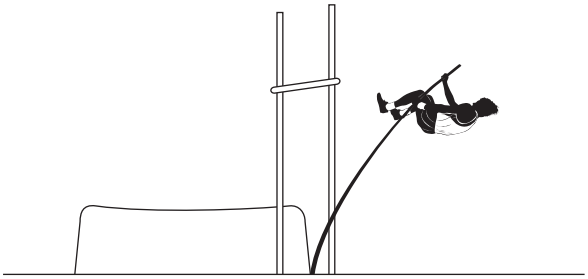
Undesirable property .....

Reason .....

.....

(4 marks)

3 (b) Modern vaulting poles are made of a carbon fibre composite material.



3 (b) (i) What is meant by a *composite material*?

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.....

(1 mark)

3 (b) (ii) What is the benefit of using a composite material?

.....

.....

(1 mark)

3 (b) (iii) Tick the boxes to show the words that describe the properties of the composite material used to make a vaulting pole.

elastic	**flexible**	**plastic**	**stiff**	**strong**	**tough**
☐	☐	☐	☐	☐	☐

(3 marks)

3 (b) (iv) Before carbon fibre vaulting poles were developed, fibre glass poles were used. These had the disadvantage of being brittle.
State what is meant by the term *brittle*.

.....

.....

(1 mark)

3 (c) A manufacturer describes a hockey stick as having a seven-ply wooden head with a carbon composite handle.

3 (c) (i) State what type of composite the head is.

.....

(1 mark)

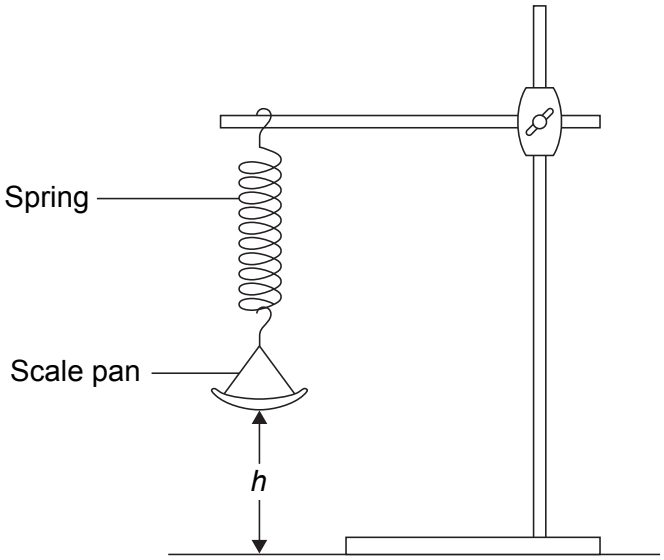
3 (c) (ii) State what type of composite the handle is.

.....

(1 mark)

13

4 The diagram shows a spring suspended from a retort stand. The spring has a scale pan attached to it.
The height of the bottom of the scale pan above the bench is labelled *h*.



A student measured values of *h* for different masses added to the scale pan. The table shows the results she obtained.

Mass added (g)	**Height of scale pan above bench, *h* (mm)**
50	184
100	172
150	160
200	148
250	136

4 (a) (i) Describe how the student would measure *h*.

.....

.....

(1 mark)

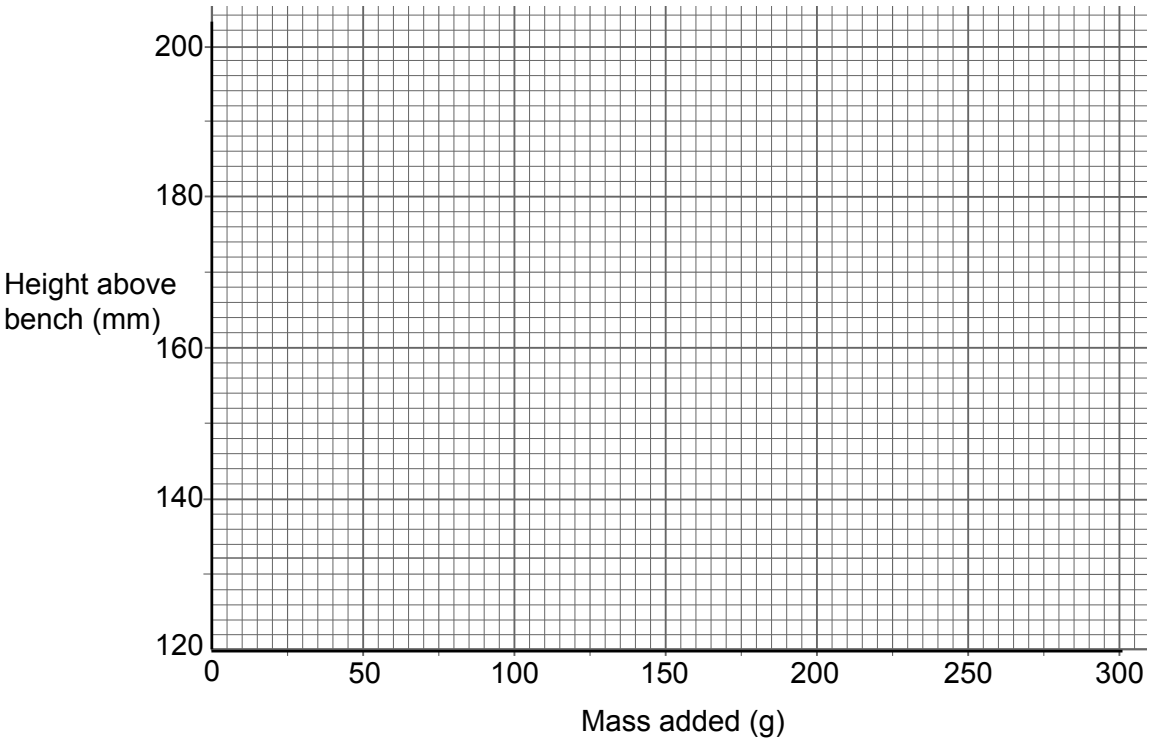
4 (a) (ii) How would she ensure that her measurements were as reliable as possible?

.....

.....

(1 mark)

4 (b) (i) Plot the data in the table on **page 6** on the graph grid below. *(1 mark)*



4 (b) (ii) Draw a line of best fit. *(1 mark)*

4 (c) (i) When the spring is unloaded, what is the height, *h*, of the scale pan above the bench?

.....

(1 mark)

4 (c) (ii) What is the height of the scale pan above the bench when a mass of 275 g is added to the scale pan?

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(1 mark)

4 (d) (i) Name the law that the spring is obeying.

.....

(1 mark)

4 (d) (ii) State the law that the spring is obeying.

.....

(1 mark)

Question 4 continues on the next page

4 (e) When a stone is added to the scale pan, the spring produces a height above the bench of 154 cm.

4 (e) (i) What is the mass of the stone?

.....

(1 mark)

4 (e) (ii) The stone has a volume of 70 cm^3.
Calculate the density of the stone.
Include the correct units in your answer.

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(3 marks)

4 (f) You are given a bottle containing a liquid.
Describe how you would measure the density of the liquid.

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(6 marks)

18

5 **Read the following article and use the information and your own knowledge to answer Question 5.**

A mouthful of materials

The inside of a person's mouth is a hostile environment. It's where saliva starts to break down food. There are strong forces as the teeth bite, chew and grind food. The temperature can change suddenly depending on what is being eaten or drunk. If a dental filling is to do its job properly it must be made of the right material.

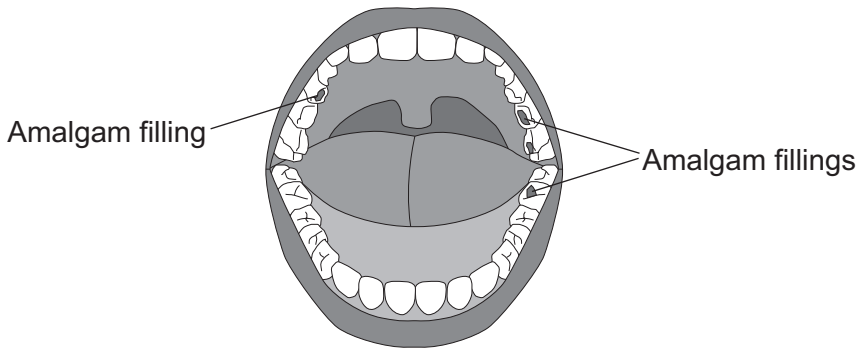
In ancient times, the material used for filling cavities in teeth was a cement made of metal oxides. In the 14th century, the method used was clearing the cavity of decayed matter, and then filling it with gold leaf. Early in the 19th century, the first dental amalgam was developed. An amalgam is an alloy of metals including mercury. The first amalgam used was made of bismuth, lead, tin and mercury. It melted at about 100ºC and was poured into the cavity at this temperature.

In the late 19th century, dentistry was revolutionised by G.V. Black. He measured the force required to chew different foods and the pressure which fillings could stand without cracking. As a result he produced a new formula for amalgam fillings. Black's formula, 65% silver, 27% tin, 6% copper and 2% zinc is still used today. Dentists mix this powder with mercury to form a paste which is put into the cavity. It is carved into shape and allowed to set and harden.

The advantages of amalgam are that it is strong and almost as hard as tooth enamel. Its disadvantages are that it conducts heat well, its thermal expansion is greater than that of a normal tooth and it does not look like tooth enamel.

Tooth fillings made of a composite material look much better than amalgam fillings. The composite is made of a plastic resin mixed with very fine particles of ground glass. Pigments are added to match the colour of the person's teeth. The dentist shines ultraviolet light on the filling to make it set hard.

The advantages of composite fillings are that they are hard and strong and that they conduct heat poorly, like the tooth itself. A disadvantage is that the thermal expansion of a composite filling is greater than that of a normal tooth.



5 (a) What is the name for a mixture of two or more metals?

.....

(1 mark)

5 (b) What is the name for a mixture of mercury with other metals?

.....

(1 mark)

5 (c) Why is gold a good metal to use for filling teeth?

.....

.....

(1 mark)

5 (d) What is the disadvantage of using gold to fill teeth?

.....

.....

(1 mark)

5 (e) How did scientific instruments help dentistry?

.....

.....

(1 mark)

5 (f) What was the disadvantage of the first dental amalgam?

.....

.....

(1 mark)

5 (g) Apart from mercury, what is the only metal in both the first dental amalgam and the amalgam used today?

.....

(1 mark)

5 (h) Both amalgam fillings and composite fillings are hard and strong. Why is this an advantage?

.....

(1 mark)

5 (i) Explain why a composite filling is better than an amalgam filling in dealing with the sudden temperature change in the mouth caused by drinking a hot drink.

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(2 marks)

5 (j) Both amalgam fillings and composite fillings have a higher thermal expansion than that of normal teeth. Why is this a disadvantage?

.....

.....

(1 mark)

5 (k) Why do composite fillings look much better than amalgam fillings?

.....

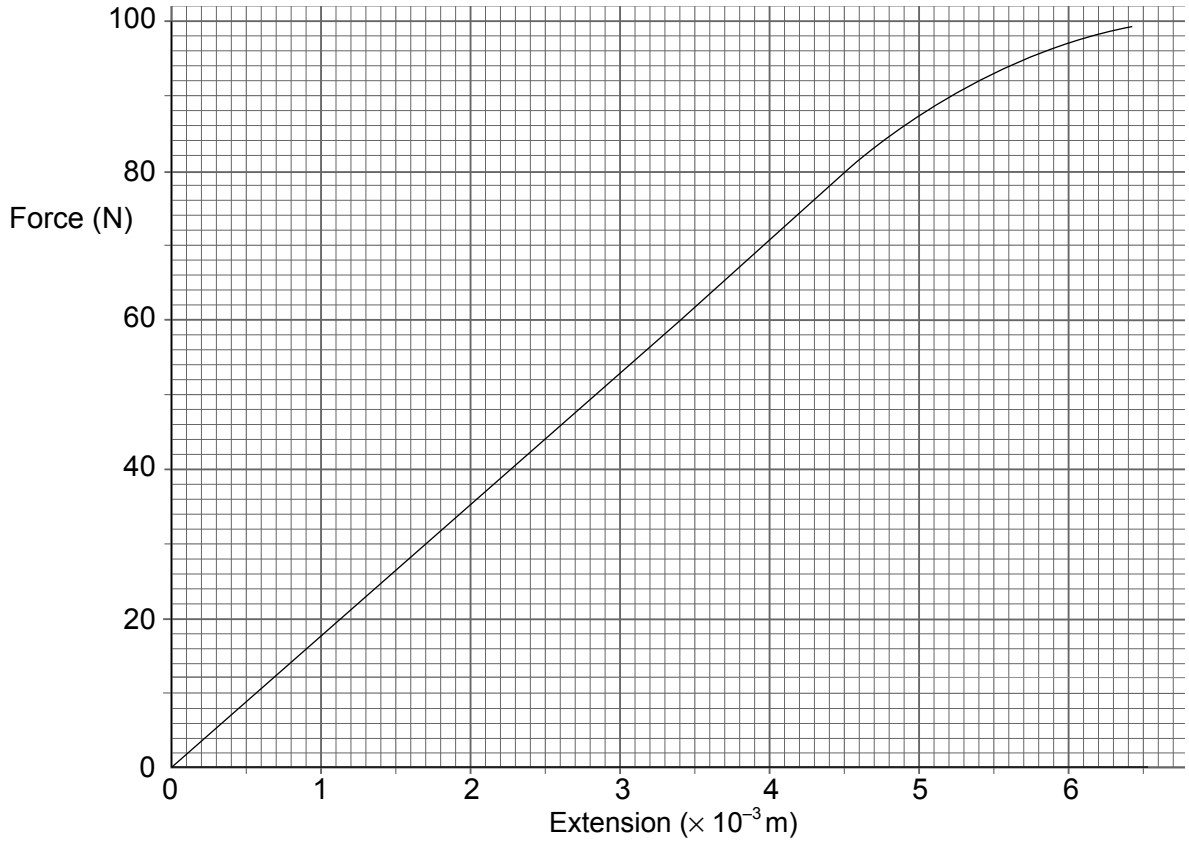
.....

(1 mark)

12

Turn over for the next question

6 Metallurgists need to have a good understanding of the properties and structure of metals in order to understand their strengths and weaknesses.
The graph shows the plot of force against extension for a copper wire.



6 (a) (i) Draw an arrow on the graph to show the elastic limit for the copper wire. *(1 mark)*

6 (a) (ii) If the copper wire is extended by a force of 90 N, describe what happens to the extension of the wire when this force is removed.

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.....

(1 mark)

6 (b) The original length of wire was 4.0 m and its cross-sectional area was 6.3×10^{-7} m^2.

6 (b) (i) Use the graph to calculate the strain in the wire for a force of 60 N.

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(2 marks)

6 (b) (ii) Calculate the stress in the wire for a force of 60 N.

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(3 marks)

6 (b) (iii) Calculate the Young modulus of copper.

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(3 marks)

6 (c) Which **one** of the following factors does not affect the stress in the wire?
Tick the box beside the correct answer.

diameter ☐

original length ☐

load ☐

cross-section area ☐ *(1 mark)*

6 (d) Explain why strain has no units.

.....

.....

(1 mark)

Question 6 continues on the next page

6 (e) Copper is very ductile.

6 (e) (i) How does the graph on **page 12** show that copper is ductile?

.....

.....

(1 mark)

6 (e) (ii) Give the name of **one** process by which copper can be treated to increase its hardness.

.....

(1 mark)

6 (f) Explain, in terms of its structure, why copper has a high electrical conductivity.

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(2 marks)

16

7 The table shows the coefficients of linear expansion for different materials.

Material	Coefficient of linear expansion ($^oC^{-1}$)
Iron	0.000012
Brass	0.000019
Aluminium	0.000026
Concrete	0.000011
Glass	0.000008

These figures can be used to calculate how much a material will expand when heated, using the formula:

expansion = original length $\times$ coefficient of linear expansion $\times$ temperature change

7 (a) If similar samples of the five materials in the table had their temperature raised by 100ºC, which **one** would expand the most?

.....

(1 mark)

7 (b) A brass rod has a length of 100 cm at 20ºC. At what temperature will its length be 100.57 cm?

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(3 marks)

Question 7 continues on the next page

7 (c) If boiling water is poured into an ordinary thick glass dish, the dish is likely to crack. Glass is a poor conductor of heat. The inside of the dish gets hot and expands but the outside stays cold and does not expand. The strain that is set up cracks the glass. If boiling water is poured into a Pyrex glass dish it does not crack.

7 (c) (i) What does this tell you about the coefficient of linear expansion of Pyrex glass compared to normal glass?

.....

.....

(1 mark)

7 (c) (ii) Explain your answer to part **(c)(i)**.

.....

.....

(1 mark)

7 (d) Glass is sometimes called an amorphous ceramic.

7 (d) (i) What does the word *amorphous* tell you about the internal structure of glass*?*

.....

.....

(1 mark)

7 (d) (ii) Name **one** type of ceramic material, other than glass.

.....

(1 mark)

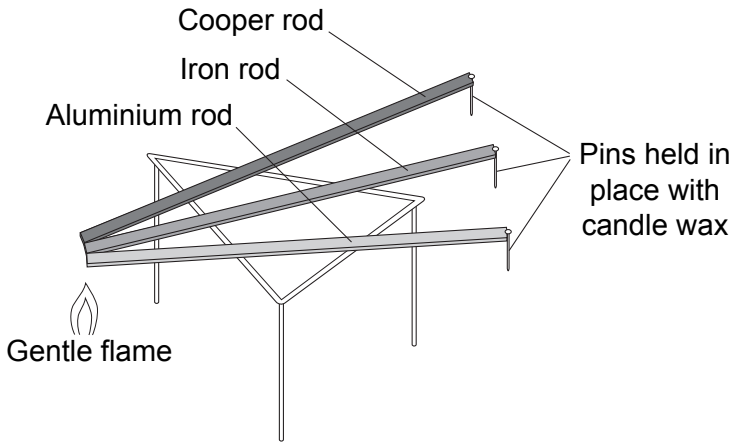
7 (e) (i) Give the definition of thermal conductivity.

.....

.....

(1 mark)

7 (e) (ii) The diagram shows apparatus used to make an approximate comparison of the thermal conductivity of three metals.



The metal rods have the same length, width and thickness.

Explain what you would see happening and how you would work out the order of thermal conductivity of the three metals.

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(3 marks)

12

END OF QUESTIONS

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