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 2013

Applied Science SC05

Unit 5 Choosing and Using Materials

Friday 11 January 2013 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 properties of materials are important in determining their use.
Here is a list of some of the properties of materials:

brittleness **elasticity** **stiffness** **strength** **hardness**

1 (a) For each of the descriptions below, write down the property from the list that is being described.

1 (a) (i) A measure of the amount of stress a material can take before fracturing.

.....

(1 mark)

1 (a) (ii) A measure of a material's resistance to bending.

.....

(1 mark)

1 (a) (iii) The tendency of a material to break or snap.

.....

(1 mark)

1 (b) Another property of materials is *plasticity.*
State the meaning of plasticity.

.....

.....

(1 mark)

1 (c) *Density* is an important physical property of materials.

1 (c) (i) Define density.

.....

.....

(1 mark)

1 (c) (ii) State **two** pieces of equipment needed to find the density of an irregularly shaped object.

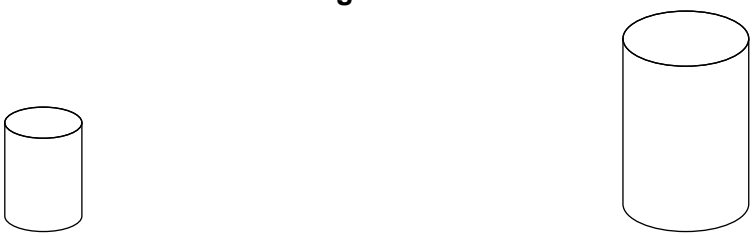
1 .....

2 .....

(2 marks)

1 (c) (iii) **Figure 1** shows two regularly shaped metal blocks.

Figure 1



One block is made from lead and the other from aluminium.
The two blocks have the same mass.
The volume of the aluminium block is 80 cm^3.

Calculate the volume of the lead block.
(Density of lead = 11.00 $g\,cm^{-3}$; density of aluminium = 2.75 $g\,cm^{-3}$).

.....

.....

.....

.....

.....

Volume = ... cm^3

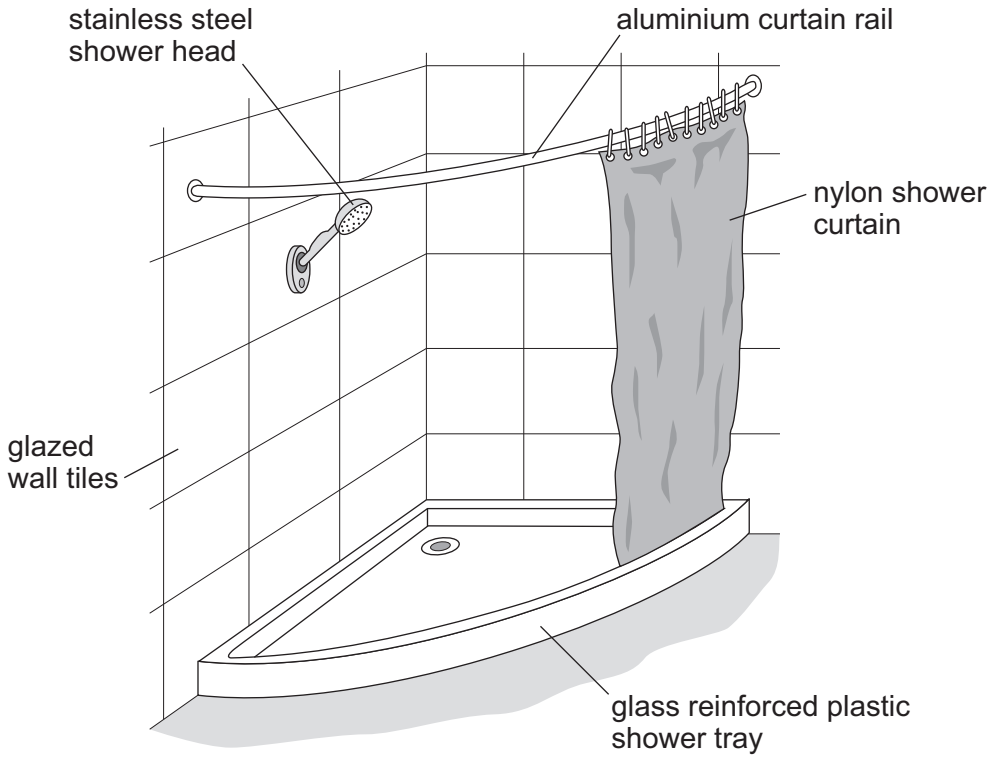
(3 marks)

10

Turn over for the next question

2 A plumber installs a new shower in a house.
Figure 2 shows the shower and the materials used.

Figure 2



2 (a) From **Figure 2** give an example of:

a polymer .....

a composite material .....

a ceramic material .....

(2 marks)

2 (b) Define the following terms:

2 (b) (i) Polymer.....

.....

(1 mark)

2 (b) (ii) Composite material.....

.....

(1 mark)

2 (c) The shower head is made from stainless steel.
Stainless steel is a mixture of iron, carbon and other metals.
What name is given to mixtures like stainless steel?

.....

(1 mark)

2 (d) Stainless steel is less *malleable* than pure iron.

2 (d) (i) What is meant by the term malleable?

.....

.....

(1 mark)

2 (d) (ii) Explain why stainless steel is less malleable than pure iron.
You may use diagrams to help your answer.

.....

.....

.....

.....

(3 marks)

2 (e) State why stainless steel, rather than ordinary steel, is used to make shower heads.

.....

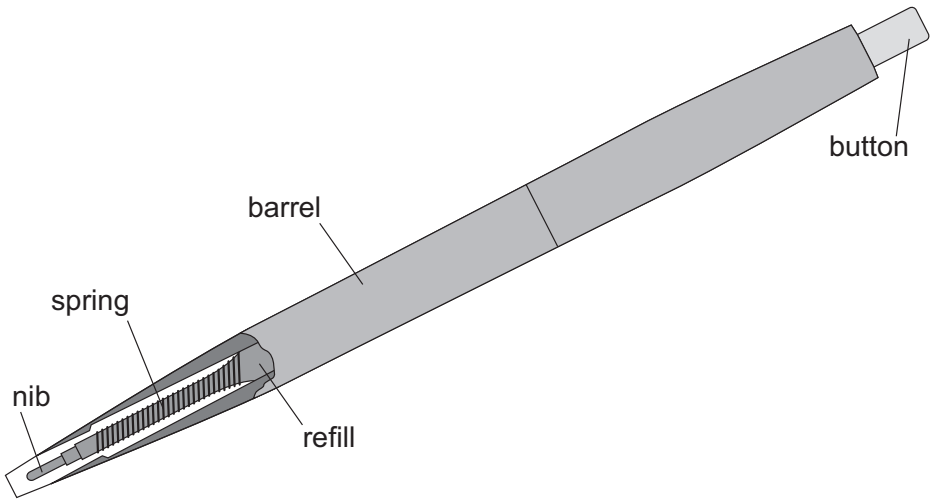
.....

(1 mark)

10

3 **Figure 3** shows a ball-point pen which has a retractable ink refill. When the button at the end of the pen is pressed the nib of the refill is pushed out of the pen and the spring is compressed. When the button is pressed again the spring pushes the refill back inside the pen.

Figure 3



3 (a) What sort of deformation must the spring undergo when it is compressed? Explain your answer.

.....

.....

.....

.....

(2 marks)

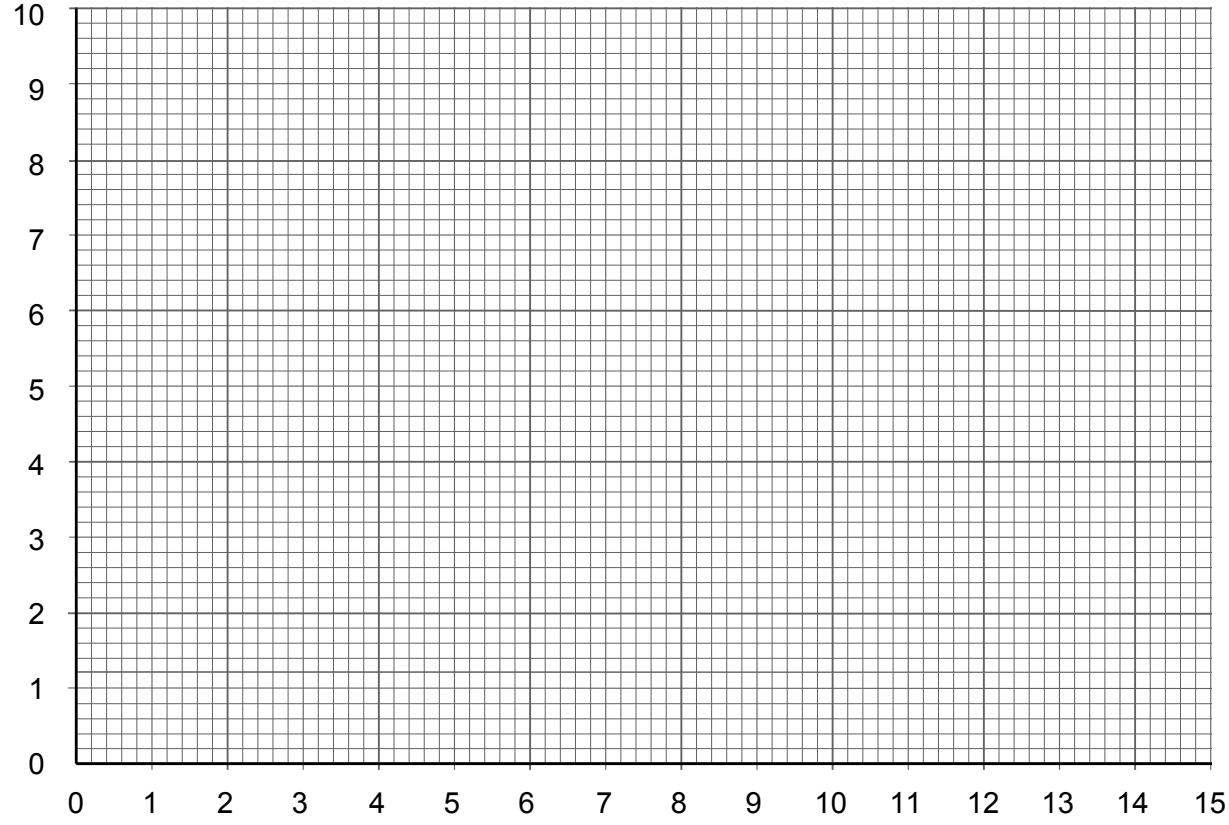
3 (b) In an experiment, an increasing force was used to compress a spring from a ball-point pen.
Table 1 shows the results obtained.

Table 1

Force (N)	Compression (mm)
0.0	0.0
1.0	1.9
2.0	3.8
3.0	5.6
4.0	7.5
5.0	9.4
6.0	11.3
7.0	13.1
8.0	15.0

3 (b) (i) Add the correct labels and units to the axes in **Figure 4.**
Plot the points given in **Table 1** and draw a line of best fit.

Figure 4



(3 marks)

3 (b) (ii) What force is needed to compress the spring by 6.0 mm?

.....

(1 mark)

3 (b) (iii) The spring from the ball-point pen is replaced with another that has double the length but is identical in all other ways.

How would the force needed to compress this new spring by 6.0 mm compare with the force needed for the original spring?

.....

.....

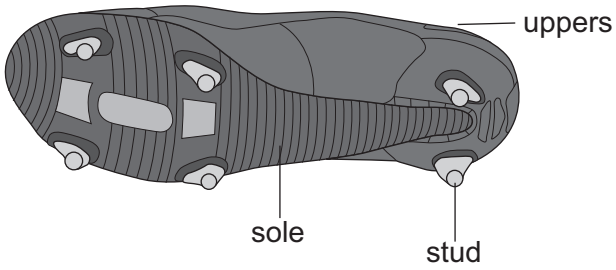
(1 mark)

7

4 Materials scientists research and develop new materials to make sports equipment and clothing.

Figure 5 shows the main parts of a football boot.

Figure 5



4 (a) The upper parts of football boots are now made using *synthetic materials* instead of leather.

4 (a) (i) What is meant by a synthetic material?

.....

.....

(1 mark)

4 (a) (ii) Give **two** advantages of using synthetic materials for the upper parts instead of leather.

Advantage 1.....

.....

Advantage 2.....

.....

(2 marks)

4 (b) The studs on the soles of football boots can be made from a variety of materials.

ceramic composite metal polymer wood

Suggest which material in the list would be the most suitable for making the studs.
Give **two** reasons for your choice.

Material .....

Reason 1 .....

.....

Reason 2 .....

.....

(2 marks)

4 (c) **Figure 6** shows a helmet used by a cricket player.

Figure 6

The face guard is made from the metal titanium.
Suggest **three** properties of titanium that make it suitable for the face guard of the helmet.

Property 1 .....

.....

Property 2 .....

.....

Property 3 .....

.....

(3 marks)

8

5 The construction industry uses large amounts of copper because it is *ductile* and is a very good electrical conductor.

5 (a) What is meant by ductile?

.....

.....

(1 mark)

5 (b) Explain, in terms of its structure, why copper is a very good electrical conductor.

.....

.....

.....

.....

(2 marks)

5 (c) Brass is used to make connectors for copper pipes.
Brass is a mixture of copper and zinc.
Table 2 shows some properties of some brasses **A**, **B** and **C**.

Table 2

Brass	Percentage copper	Percentage zinc	Relative hardness	Relative thermal conductivity
A	90	10	65	43
B	70	30	70	27
C	60	40	73	21

5 (c) (i) What is the relationship between the thermal conductivity of brass and the amount of copper it contains?

.....

.....

(1 mark)

5 (c) (ii) Define thermal conductivity.

.....

.....

(1 mark)

5 (c) (iii) Use information from **Table 2** to explain whether copper or zinc is the harder metal.

.....

.....

.....

.....

(2 marks)

5 (d) The properties of metals can be changed by mixing them with other metals or by heat treatment.
Name **two** methods of heat treatment that alter the properties of metals and describe how each method is carried out.

Method 1 .....

Description .....

.....

Method 2 .....

Description .....

.....

(4 marks)

5 (e) Metals expand when heated.
It was found that a 25 cm length of steel rod expanded by 0.025 mm when heated from 20 °C to 100 °C.

5 (e) (i) Calculate the expansion of a 1 cm length of the same steel rod for a 1 °C rise in temperature.

.....

.....

.....

.....

.....

Expansion = ... mm

(2 marks)

Question 5 continues on the next page

5 (e) (ii) What name do we give to the increase in length of a 1 cm length of material for a 1 °C rise in temperature?

.....

(1 mark)

5 (e) (iii) Give **one** example of a way in which an understanding of the expansion of materials would be valuable to an engineer or builder.
Describe any precautions that might be taken as a result.

.....

.....

.....

.....

.....

.....

(3 marks)

17

Turn to page 14 for the next question

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

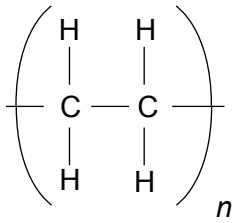
6 **Read the following article about plastic waste and use the information and your own knowledge to answer the questions that follow.**

Plastic waste

Although polymers are very useful materials there are problems with the disposal of unwanted plastic articles. Many polymers made from crude oil, such as poly(ethene), are not *biodegradable* and so cause unsightly rubbish, harm wildlife and take up valuable space in landfill sites.

Figure 7 shows the structure of poly(ethene).

Figure 7



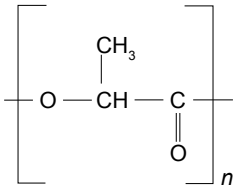
poly(ethene)

Burning polymers is not a good way of disposing of them because toxic materials are produced. Some polymers can be recycled. Once sorted into different types, they can be melted down and made into new products. However, recycling polymers is not as cost effective as recycling paper, glass or metals.

Biodegradable polymers are now being developed and will increasingly replace many of the traditional polymers in use today. Poly(lactic acid), or PLA, is a *bioplastic* that is biodegradable. Not all bioplastics are biodegradable. PLA is used to make sandwich containers, plastic cups and plastic cutlery. PLA is made from cornstarch, which is obtained from the maize plant. To make PLA the cornstarch is fermented using microbes to make lactic acid, which is then *polymerised*.

Figure 8 shows the structure of PLA.

Figure 8



PLA

6 (a) Suggest what is meant by the term bioplastic.

.....

.....

(1 mark)

6 (b) Give the meaning of the following terms used in the article.

Biodegradable.....

.....

Polymerise .....

.....

(2 marks)

6 (c) How does recycling plastic waste and using plastics such as PLA help to conserve our supplies of crude oil?

.....

.....

(1 mark)

6 (d) What is the name of the monomer from which PLA is made?

.....

(1 mark)

6 (e) (i) What type of chemical bonding is present in the polymers poly(ethene) and PLA?

.....

(1 mark)

6 (e) (ii) Describe this type of bonding.

.....

.....

(1 mark)

6 (f) Give **one** way in which the structure of PLA is similar to the structure of poly(ethene).

.....

.....

(1 mark)

6 (g) Give **one** way in which the structure of PLA is different from the structure of poly(ethene).

.....

.....

(1 mark)

9

7 (a) (i) Define strain.

.....

.....

(1 mark)

7 (a) (ii) Define stress.

.....

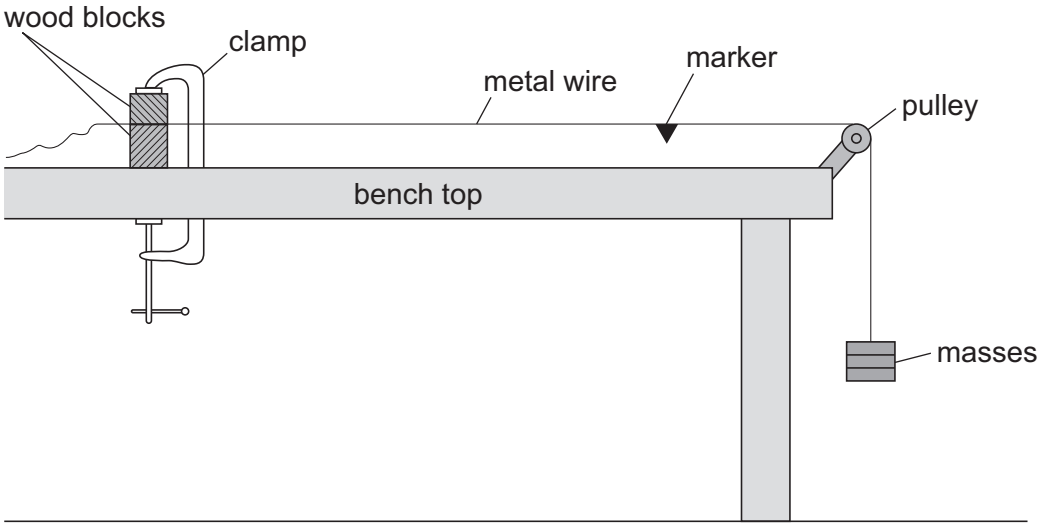
.....

(1 mark)

7 (b) Describe an experiment to determine the Young modulus of a metal in the form of a wire.
You are to use a method that involves drawing a graph. Assume that standard laboratory apparatus is available.

Figure 9 shows some of the apparatus to be used.

Figure 9



7 (b) (i) List any additional apparatus needed but not shown in **Figure 9**.

.....

.....

(2 marks)

7 (b) (ii) State the measurements to be made.

.....

.....

.....

.....

(2 marks)

7 (b) (iii) Describe how the equipment is used to make the measurements.

.....

.....

.....

.....

.....

.....

.....

.....

(4 marks)

7 (b) (iv) Describe how the measurements are used to determine the Young modulus. You are to use a method that involves drawing a graph.

.....

.....

.....

.....

.....

.....

.....

.....

(4 marks)

Question 7 continues on the next page

7 (b) (v) Identify **one** hazard in the experiment and state the precaution taken to minimise the hazard.

.....

.....

(1 mark)

7 (c) A metal wire is 1.84 m long and has a cross-sectional area of 1.64×10^{-7} m^2. When a load of 35 N is applied to the wire it extends by 1.25 mm.

Calculate the Young modulus of the metal. Give the correct unit in your answer.

.....

.....

.....

.....

.....

.....

.....

.....

Young modulus = ...

(4 marks)

19

END OF QUESTIONS

There are no question printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

There are no question printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED