Centre Number						Candidate Number				
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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
June 2014

Applied Science SC05

Unit 5 Choosing and Using Materials

Thursday 15 May 2014 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

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 Polymers are very useful materials.

1 (a) What is meant by a **polymer**?

[1 mark]

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1 (b) Many polymers are manufactured from materials that are obtained from crude oil.
Give **two** disadvantages of the increasing use of these polymers.

[2 marks]

1 .....

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2 .....

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1 (c) **Table 1** shows the important properties of some polymers.

Table 1

Polymer	Properties
Polystyrene	Easily moulded Can be expanded into foam
Polythene	Strong Easily moulded
Polypropene	Forms strong fibres Highly elastic
PTFE	Hard Waxy Things do not stick to it
Perspex	Transparent Easily moulded Does not easily shatter

Use the information in **Table 1** to decide which polymer is the most suitable for each of the uses listed in **Table 2**.

In each case state **one** property that makes it suitable.

[6 marks]

Table 2

Use	Polymer	Property
Making carpets		
Making heat-insulating material		
Making picnic glasses		

1 (d) Injection moulding is used to manufacture items like window frames and garden furniture.
Injection moulding involves injecting liquid polymers into a mould.

1 (d) (i) Why can polymers be used in injection moulding?

[1 mark]

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1 (d) (ii) Suggest why a factory that uses injection moulding will have a high electricity bill.

[1 mark]

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11

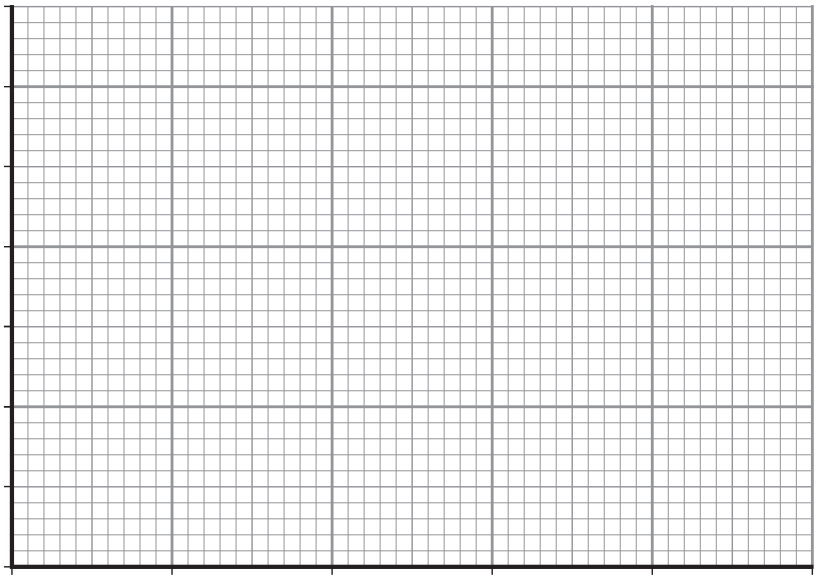
2 **Table 3** shows the readings taken during an experiment using a spring to investigate Hooke's law.

Table 3

Force (N)	0	1	2	3	4	5	6
Length (mm)	20	26	32	38	44	54	90

2 (a) (i) Plot the data in **Table 3** onto the grid provided below.
Plot length on the *x*-axis and force on the *y*-axis.
Label the axes, add appropriate units and draw a line of best fit.

[3 marks]



2 (a) (ii) Explain why the graph does not pass through the origin.

[1 mark]

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2 (a) (iii) State Hooke's law.

[1 mark]

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2 (a) (iv) Over what range of force is it certain that the spring in this experiment obeys Hooke's law?
Give a reason for your answer.

[2 marks]

Range from .....N to .....N

Reason .....

.....

2 (a) (v) Use your graph to find the force needed to make the spring extend by 22 mm.

[1 mark]

.....

Force = ……N

2 (b) A different spring is 20 cm long when a load of 10 N is hanging from it, and 38 cm long when a load of 25 N is hanging from it. The spring does not pass its elastic limit.

What is the length of the spring when:

2 (b) (i) there is no load on it?

[1 mark]

.....

.....

Length = ...cm

2 (b) (ii) there is a load of 5 N on it?

[1 mark]

.....

.....

Length = ...cm

10

3 A materials scientist investigated different fibres to see which would be best for making rugby players' shirts.

Table 4 shows his findings.

Table 4

	Wool	**Polypropylene**	**Cotton**	**Polyester**
Relative density	1.32	0.91	1.54	1.38
Relative absorbency	16.00	0.05	8.00	0.40
Colour fastness	May fade when washed	Very good. Pre-coloured in manufacture	May fade when washed	Good
Durability	Fair	Excellent	Fair	Excellent
Stain resistance	Requires dry cleaning for stain removal	Resists staining	Requires bleaching for stain removal	Requires chemicals for stain removal

3 (a) Which fibre would the scientist choose as being most suitable for making rugby players' shirts?
Use the information in **Table 4** to explain your answer.

[3 marks]

Fibre.....

Explanation .....

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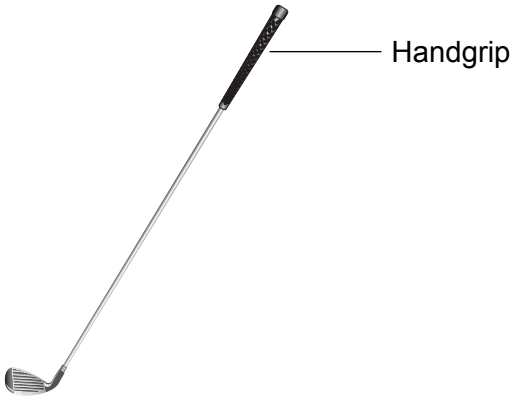
3 (b) A manufacturer of golf clubs is looking at materials to use for making handgrips for the clubs. **Figure 1** shows a golf club.

Figure 1



The manufacturer wants the handgrip to feel warm.
Table 5 shows the thermal conductivity for four materials, **A**, **B**, **C** and **D**.

Table 5

Material	**Thermal conductivity (W m^{-1} K^{-1})**
A	4.61
B	0.14
C	0.04
D	0.19

Which material, **A**, **B**, **C** or **D**, would be best to use to make the handgrip?
Give a reason for your answer.

[3 marks]

Material.....

Reason .....

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6

4 Mortar and concrete are used extensively in the construction industry.

A technician mixes sand, cement and water in different proportions to make three samples of mortar. She wants the mortar to be strong in compression.

4 (a) What is meant by the term **strong in compression**?

[1 mark]

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4 (b) The technician wants to test the compressive strength of the three samples of mortar once they have set. Each sample has the same dimensions.

Describe a suitable method that the technician could use in a laboratory.
You may draw a diagram to help your answer.

[5 marks]

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4 (c) Concrete is formed when gravel is added to a mortar mix.
Concrete is a composite material that is stronger in compression than mortar.
However, concrete is weak in tension.

4 (c) (i) What is meant by the term **weak in tension**?

[1 mark]

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4 (c) (ii) How can concrete be made stronger in tension?

[1 mark]

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4 (c) (iii) A concrete paving slab has a mass of 45 kg and measures 0.60 m × 0.60 m × 0.05 m.

Calculate the density of the concrete. Give the correct unit in your answer.

[3 marks]

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Density = ...

4 (c) (iv) Apart from mortar and concrete, give **one** other example of a composite material and state **one** use for the material.

[2 marks]

Material .....

Use .....

.....

13

5 **Read the following article about metals.**
Use the information in the article and your own knowledge to answer the questions that follow.

Metals

Metals are very useful materials because of their properties.

- Most metals have a high ultimate tensile strength.
- Metals are malleable and ductile.
- Metals are good conductors of heat and electricity.

A few metals, such as silver and gold, are found in the Earth as the metals themselves. Silver and gold are said to occur native.

Other metals are found in the Earth as compounds, usually as the metal oxide. If there is enough metal oxide in a rock to make it economical to extract the pure metal, the rock is called an ore. The process of extracting a metal from its ore is called smelting.

The way in which a metal is extracted from its ore depends on how reactive the metal is. The more reactive the metal, the more difficult it is to extract it from its ore. Fairly reactive metals, such as iron and zinc, are obtained by heating their ores with carbon in a furnace. Very reactive metals, such as aluminium and sodium, can only be obtained from their ores using electrolysis. In this process, the ore is melted and an electric current is passed through it to obtain the metal.

5 (a) Give the definitions of the following terms.

[3 marks]

Ultimate tensile strength.....

.....

Malleable .....

.....

Ductile .....

.....

5 (b) Explain, in terms of their structure, why metals are good conductors of electricity.

[2 marks]

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5 (c) Platinum occurs native. What does this tell you about the reactivity of platinum?

[1 mark]

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5 (d) Define the word **ore**.

[2 marks]

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5 (e) Magnesium is more reactive than aluminium. Which method of smelting would be used to extract magnesium from its ore?

[1 mark]

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5 (f) Suggest why aluminium was discovered several thousand years after iron.

[1 mark]

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10

6 Manufacturers can use various techniques to alter the properties of materials.

6 (a) Alloying metals changes their properties.
Brass is an alloy made by adding a small amount of zinc to some copper.

6 (a) (i) Complete **Table 6** by putting **one** tick in each row.

[2 marks]

Table 6

	Brass	**Pure copper**
Which is stronger?		
Which is more malleable?		
Which is less ductile?		

6 (a) (ii) Explain, in terms of its metallic structure, why brass is less dense than pure copper.

[2 marks]

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6 (b) Some metals can be made harder by the process of quenching.
Describe how **quenching** is performed.

[2 marks]

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6 (c) Glass can be made stronger and harder by the process of annealing.

6 (c) (i) Describe how **annealing** is performed.

[2 marks]

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6 (c) (ii) Apart from strength and hardness, state **one** other change in the properties of glass after it has been annealed.

[1 mark]

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

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

[1 mark]

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6 (d) (ii) Apart from glass, name **one** other type of ceramic material and state **one** use of this material.

[2 marks]

Material .....

Use .....

.....

Question 6 continues on the next page

6 (e) Polymers can be made stronger by the process of cold drawing.

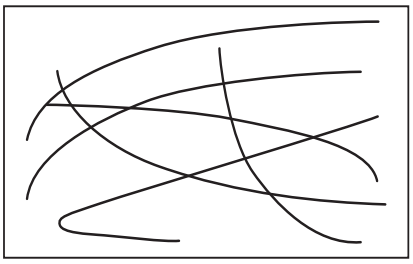
The diagram in the left-hand box of **Figure 2** shows polymer molecules before cold drawing.

Complete the right-hand box to show the arrangement of the polymer molecules after cold drawing.

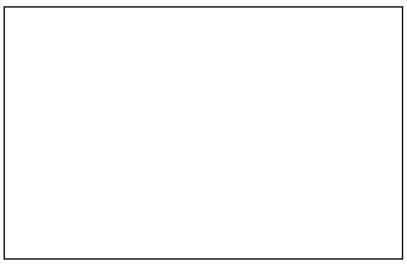
[1 mark]

Figure 2

Before cold drawing



After cold drawing



13

Turn over for the next question

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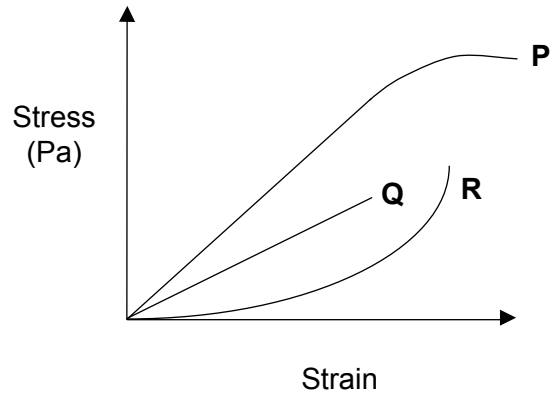
ANSWER IN THE SPACES PROVIDED

7 **Figure 3** shows stress against strain graphs for three materials, **P**, **Q** and **R**, up to their breaking points.

Figure 3



7 (a) (i) Define the term **stress**.

[1 mark]

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7 (a) (ii) Define the term **strain**.

[1 mark]

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7 (a) (iii) Why is there no unit for strain?

[1 mark]

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7 (b) (i) Which material, **P**, **Q** or **R**, is the most brittle?
Use **Figure 3** to explain your answer.

[2 marks]

Material .....

Explanation .....

.....

7 (b) (ii) Which material, **P**, **Q** or **R**, has the biggest value for its Young modulus? Explain your answer.

[2 marks]

Material .....

Explanation .....

.....

7 (c) Engineers are testing a new material to be used to make support cables for bridges. In a laboratory test, the breaking force for a sample of the material of cross-sectional area 0.82 mm^2 was 240 N.

A cable made from the same material has a cross-sectional area of 1.23 mm^2. Calculate the breaking force for this cable.

[2 marks]

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Breaking force = ...N

7 (d) Kevlar is one of the strongest synthetic materials. Sudden impacts cause Kevlar to undergo plastic deformation.

7 (d) (i) What is meant by a **synthetic** material?

[1 mark]

.....

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7 (d) (ii) What is meant by **plastic deformation**?

[1 mark]

.....

.....

Turn over ▶

7 (e) One particular type of Kevlar has a breaking stress of 2.00×10^{8} Pa and a Young modulus of 1.40×10^{11} Pa.
For a Kevlar fibre with a cross-sectional area of 1.32×10^{-6} m^2 and a length of 0.50 m, calculate:

7 (e) (i) the fibre's maximum breaking force

[2 marks]

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Maximum breaking force = ...N

7 (e) (ii) the extension of the fibre when the stress on it is 1.25×10^{8} Pa.

[4 marks]

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Extension = ...m

17

END OF QUESTIONS

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