

Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

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General Certificate of Education  
 June 2006  
 Advanced Subsidiary Examination



**APPLIED SCIENCE**  
**Unit 5 Choosing and Using Materials**

**SC05**

Thursday 8 June 2006 1.30 pm to 3.00 pm

<p><b>For this paper you must have:</b></p> <ul style="list-style-type: none"> <li>• a pencil and ruler</li> <li>• a calculator</li> </ul>
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Time allowed: 1 hour 30 minutes

**Instructions**

- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want marked.
- Show the working of your calculations.

**Information**

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

For Examiner's Use			
Number	Mark	Number	Mark
1		5	
2			
3			
4			
Total (Column 1)		→	
Total (Column 2)		→	
TOTAL			
Examiner's Initials			

**There are no questions printed on this page**

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

**1** The car industry uses aluminium to make some car components.  
You have been given a sample of aluminium to test in a school laboratory.

(a) (i) Plan an experiment that you could carry out in a school laboratory to measure the breaking stress (strength) of the aluminium sample.

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*(3 marks)*

(ii) What **two** measurements would you use to calculate the breaking stress of the aluminium sample?

1 .....  
2 .....

*(2 marks)*

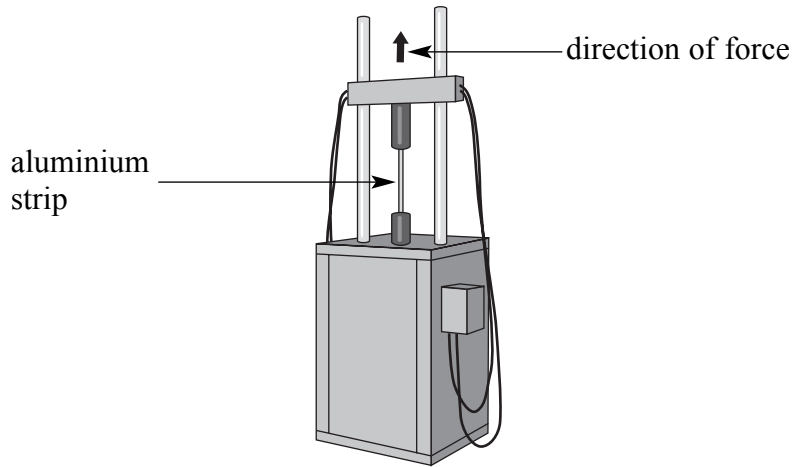
(iii) How would you make sure your test results are reliable?

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.....  
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*(2 marks)*

**Question 1 continues on the next page**

- (b) When the breaking stress of aluminium is measured in an industrial laboratory an aluminium strip is put under tension. The diagram below shows a typical piece of equipment that is used in industry.



Describe how the shape of the aluminium strip will change when put under tension.

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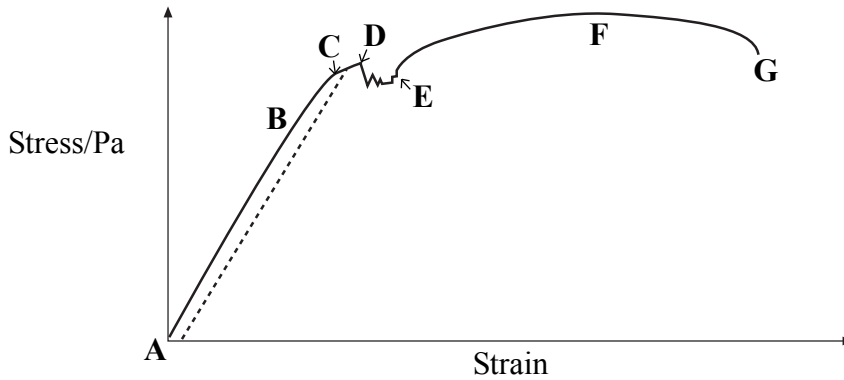
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*(2 marks)*

(c) The graph below shows the stress–strain curve obtained for the sample of aluminium under test.

Use the letters **A – G** from the graph to answer parts (c)(i) to (c)(iii) which follow.



(i) Complete the table below with the information from the graph above.

Description	Letter or letters
The yield point	
	A to B
The elastic limit	
The region where plastic deformation (plasticity) has occurred	
	G

(5 marks)

(ii) Describe what will happen to the sample of aluminium under test if the stress is removed before point C.

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(2 marks)

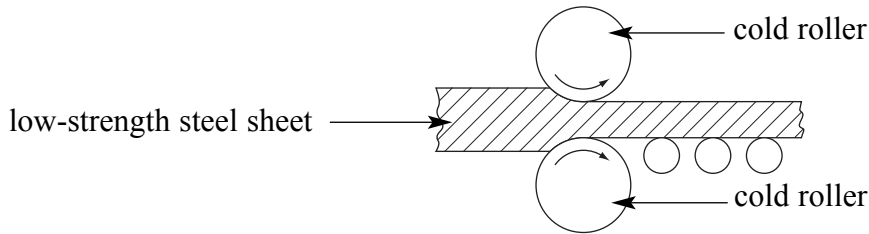
(iii) There is a dotted line shown on the graph above. What does this dotted line signify?

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.....

(1 mark)

- 2 The drinks can industry produces nearly 3.5 billion cans every year. These cans are made from sheets of low-strength steel. The diagram below shows how sheets of low-strength steel are cold rolled to reduce the thickness of the sheet before shaping.



- (a) Cold rolling introduces unwanted stresses and strains into the steel. Therefore heat treatment is required before shaping can take place.

(i) Suggest a suitable type of heat treatment process for this.

.....  
(1 mark)

(ii) Describe how this process is carried out.

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.....  
(3 marks)

- (b) After heat treatment the steel sheets become more ductile.

(i) What does the term *ductile* mean?

.....  
.....  
(1 mark)

(ii) Why do makers of drinks cans prefer to use steel that is ductile?

.....  
.....  
.....  
.....  
(2 marks)

(iii) Use your knowledge of the structure of steel to explain why it is ductile.

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(3 marks)

(c) Once shaped and formed, the steel cans then move on to another part of the production process that involves protecting them from the environment. Protective coatings or barriers are applied.

(i) Name a type of protective coating that could be applied to the steel can.

.....

(1 mark)

(ii) What does the protective coating resist?

.....

.....

(1 mark)

(iii) What would happen to the mechanical properties of the steel if it did **not** have a protective coating?

.....

.....

(1 mark)

(d) Manufacturers of steel cans are always looking for ways of reducing their manufacturing costs.

(i) How can cold rolling be used to further reduce the manufacturing cost of the steel cans?

.....

.....

(1 mark)

(ii) How can the cost of heat treatment be reduced?

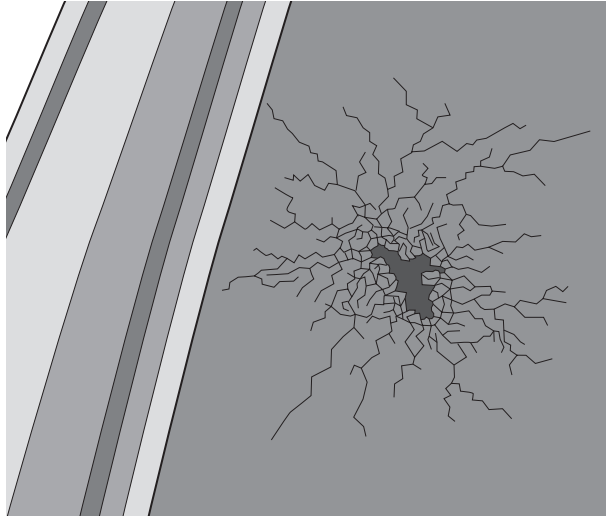
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(1 mark)

- 3 Car and glass technologists invest a great deal of time and money improving the properties of the glass used in windscreens.

In recent years, technology has advanced greatly but many windscreens still need replacing as a result of the material failing or being damaged as shown below.



A lump of glass behaves like a solid. The arrangement of the atoms in the solid glass is disorganised.

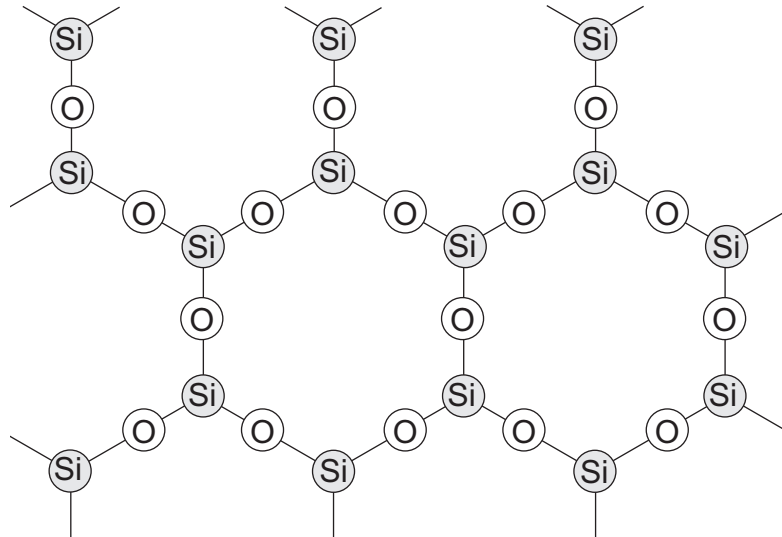
- (a) What name do we give to this type of structure?

.....  
(1 mark)



- (b) Glass technologists use powerful microscopes to view the structure of materials.

Some forms of glass are crystalline and consist of three-dimensional giant structures of atoms as shown below.



- (i) What type of bonding is shown in the diagram above?

.....  
(1 mark)

- (ii) Silicon dioxide (sand) is used to make glass. Give **one** reason why it is difficult to process this material.

.....  
(1 mark)

- (c) Glass, made for a particular purpose, has to have an appropriate density.

A sample of glass has a mass of 2700 kg and a volume of  $1.1 \text{ m}^3$ .

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

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.....  
.....  
.....

(3 marks)

Question 3 continues on the next page

(d) Glass can be described as a low toughness (mechanical property), high refractive index (physical property) material.

(i) Give **one** other mechanical property of glass.

.....  
(1 mark)

(ii) Give **one** other physical property of glass.

.....  
(1 mark)

(e) Untreated glass is a weak material, it has many very small cracks on the surface and very small defects within the body of the glass.

Describe what happens to these cracks when the material becomes stressed.

You may include a diagram to illustrate your answer.

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(2 marks)

(f) Glass needs to be heat treated before it is used in a car windscreen.

(i) Suggest a suitable heat treatment process for this glass.

.....  
(1 mark)

(ii) Describe how the heat treatment process you have suggested is carried out.

.....  
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.....  
(2 marks)

(iii) Explain how, following heat treatment, changes in the mechanical properties make the glass suitable for use as a car windscreen.

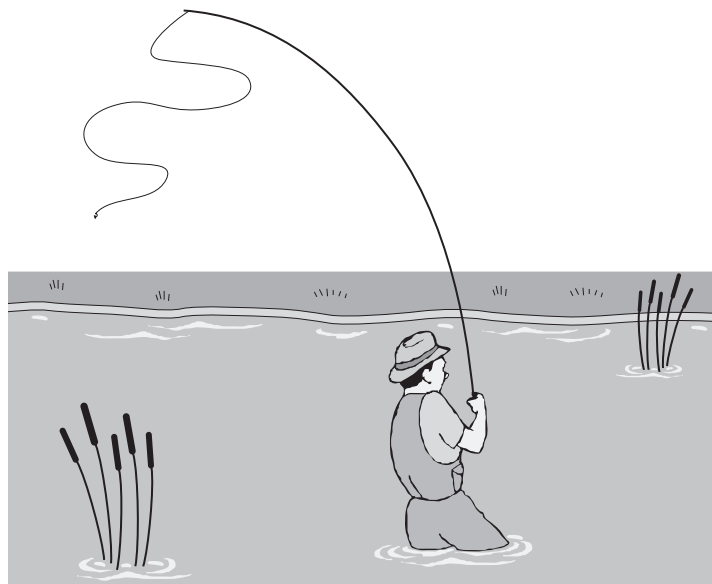
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(3 marks)

**Turn over for the next question**

4 Read the following information about the changes in fishing rods over the last 30 years.

Over the last 30 years, the choice of materials used to make fishing rods has increased. During this time, not only has glass become available as a fibre (fibreglass) but also other materials such as carbon, boron, Kevlar and polymers have been developed. In the past, fishing rods were usually made from cane or fibre type bamboo.

The weight of a fishing rod affects how well it handles. Reducing the weight means the fisherman can comfortably move to a longer rod. Moving to a lighter and stronger material increases stored energy which can be released instantaneously as the fishing rod straightens during casting. The diagram below shows a fisherman casting a fishing rod.



Strength is another important property. Material failure is most likely to happen in compression at the weakest point of the system. It is, therefore, very important to ensure that the fibre properties and their interaction with the polymer (matrix) resin are maintained.

Use your own knowledge and the information given in the passage on **page 12** to answer the questions that follow.

- (a) (i) From what type of material are modern fishing rods made?

.....  
(1 mark)

- (ii) Explain the purpose of the resin used in combination with the fibres.

.....  
.....  
.....  
.....  
(2 marks)

- (b) From the information given on **page 12**, state **two** properties that are essential for the requirements of a modern day fishing rod.

1 .....

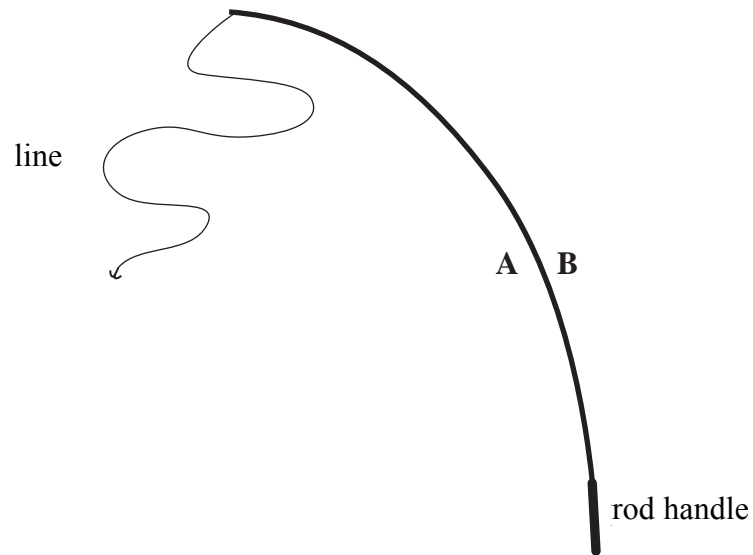
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2 .....

.....  
(2 marks)

**Question 4 continues on the next page**

(c) The diagram below shows the fishing rod during casting.



Identify the type of stress acting at:

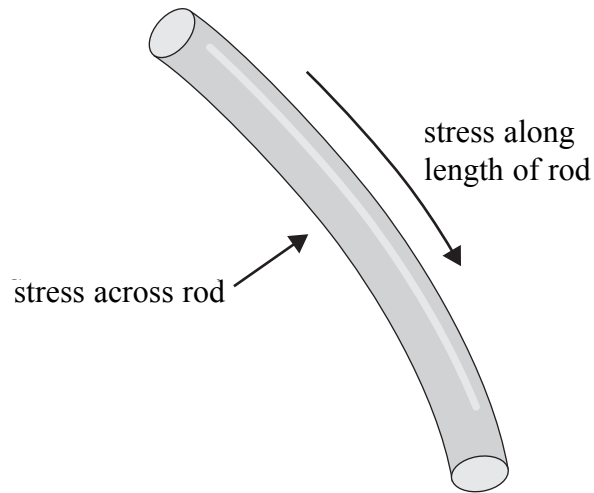
(i) point **A** on the left hand side of the fishing rod;

.....  
(1 mark)

(ii) point **B** on the right hand side of the fishing rod.

.....  
(1 mark)

- (d) The diagram below shows a section of the fishing rod during casting.



Using the diagram above, explain why the material along the length of the rod requires a higher elastic modulus than across the length.

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.....

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*(2 marks)*

- (e) Explain why fishing rods made from carbon/graphite fibres have to be used very carefully when fishing near overhead electrical cables.

.....

.....

.....

*(2 marks)*

**Question 4 continues on the next page**

(f) A fisherman is looking to buy a new high performance fishing rod. His priorities, in order of importance are:

- low cost
- high stiffness
- low weight
- high strength

He uses the Internet to investigate some possible materials and collects the information shown in the table below.

Rod	Fibre/ type	Cost (£/kg)	Stiffness (GPa)	Density (kg m <sup>-3</sup> )	Strength (GPa)
A	Glass	4	80	2.5	4.0
B	Carbon	20	400	1.9	2.5
C	Boron	250	450	2.5	4.0

(i) With the fisherman's priorities in mind, which rod, **A**, **B** or **C**, should he choose?

.....  
(1 mark)

(ii) Give **three** reasons for your choice by explaining how the properties of the chosen rod relate to the fisherman's requirements.

1 .....

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2 .....

.....

3 .....

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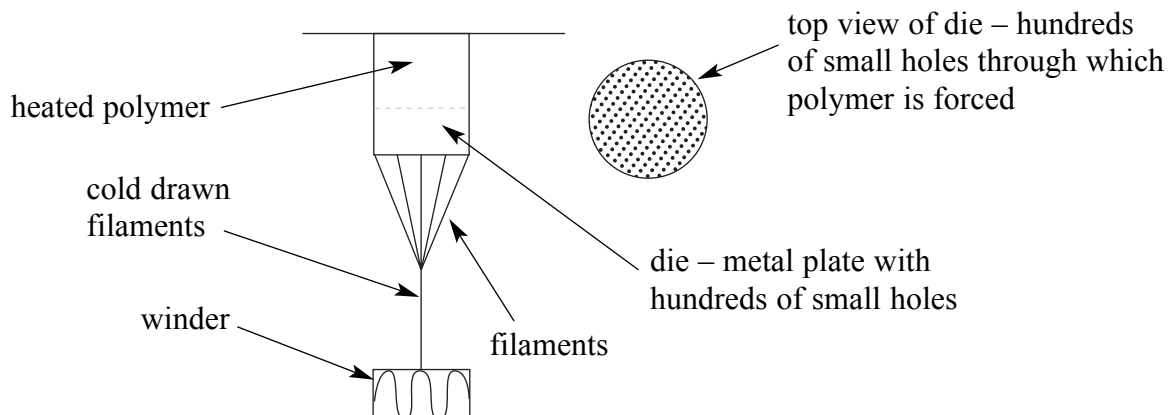
(3 marks)



5 Many modern sports shoes and trainers make use of nylon.

The nylon used is woven as fibre into a fabric.

The diagram below shows how the nylon is processed into fibres. The nylon, in granule form, is heated inside the die and forced through it using pressure. Filaments emerge from the die looking like thin spaghetti. The filaments are pulled together and cold drawn in a continuous process. The fibre is collected onto a winder and later processed to make fabric for sports shoes.



- (a) (i) What type of material is nylon?

.....  
(1 mark)

- (ii) Describe the molecules in this type of material.

.....  
.....  
(1 mark)

**Question 5 continues on the next page**

- (b) (i) The density of nylon is  $1.3 \text{ g cm}^{-3}$ . Explain why having a low density makes nylon suitable for use in sports shoes and trainers.

.....  
.....  
.....  
(2 marks)

- (ii) Suggest **two** further properties, other than low density, which makes nylon suitable for use in sports shoes.

1 .....

2 .....

(2 mark)

- (c) (i) Nylon is a thermoplastic. Name **one** other type of thermoplastic.

.....  
(1 mark)

- (ii) What does the term *thermoplastic* mean?

.....  
.....  
(1 mark)

- (d) As the melted nylon comes out of the die, the molecules become tangled together. Cold drawing is used to align the molecules.

- (i) Explain how cold drawing improves the mechanical properties of the nylon.

.....  
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.....  
(2 marks)

- (ii) Explain how thermosetting plastics differ from thermoplastics in terms of their molecular structure.

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.....  
(2 marks)

Question 5 continues on the next page

(e) A materials technologist used a tensiometer to measure the breaking stress and strain of the nylon fibre.

(i) What do these terms mean?

*Stress*

.....  
.....

*Strain*

.....  
.....

(2 marks)

(ii) The average breaking stress of the nylon fibre was found to be  $7 \text{ kN mm}^{-2}$  and the strain was found to be 0.05.

Use these values to calculate the Young modulus (stiffness) of the nylon.

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(3 marks)

**END OF QUESTIONS**

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