Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

For Examiner's Use

General Certificate of Education
January 2010
Advanced Subsidiary Examination

APPLIED SCIENCE **SC05**
Unit 5 Choosing and Using Materials

Tuesday 12 January 2010 9.00 am to 10.30 am

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

Time allowed: 1 hour 30 minutes

Instructions
- Use black ink or black ball-point pen. Use pencil only for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Answers written in margins or on blank pages will not be marked.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- Show the working of your calculations.

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

For Examiner's Use			
Question	Mark	Question	Mark
1		5	
2		6	
3		7	
4			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

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

1 The materials used by scientists and engineers include metals, polymers, ceramics, glass and composites.

1 (a) (i) Give **one** reason why metals are used to make car bodies.

.....

.....

(1 mark)

1 (a) (ii) Give **one** reason why ceramics are **not** suitable materials for making car bodies.

.....

.....

(1 mark)

1 (b) Gutters and drainpipes used to be made from iron. Now they are made from plastics (polymers).
Give **two** properties of plastics that make them better materials than iron for making gutters and drainpipes.

Property 1 .....

.....

Property 2.....

.....

(2 marks)

1 (c) Skateboards can be made from glass-reinforced plastic (GRP).

1 (c) (i) GRP is a composite. What is meant by a *composite* material?

.....

.....

(1 mark)

1 (c) (ii) Plastic alone would not be suitable for making skateboards. Suggest **two** reasons why GRP is better.

Reason 1 .....

.....

Reason 2 .....

.....

(2 marks)

1 (d) Plastics are generally cheaper than glass. They are also more difficult to break. However, glass is still more widely used than transparent plastic for making windows. Suggest a reason for this.

.....

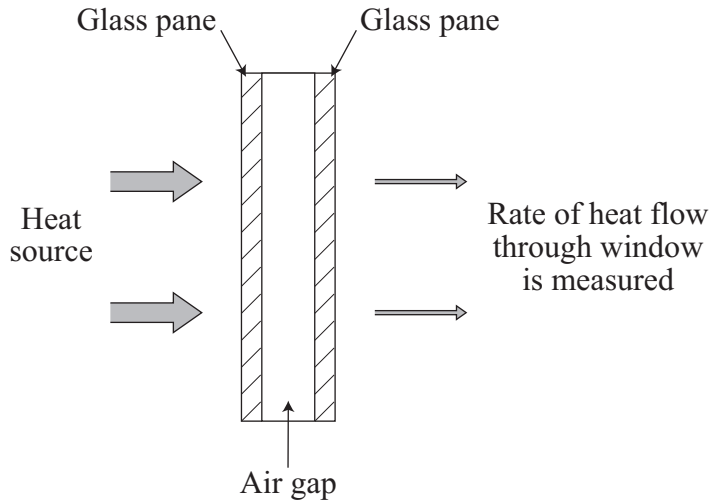
.....

(1 mark)

8

Turn over for the next question

2 A manufacturer carries out some tests to find out the best size of air gap to use between the two panes of glass in double-glazed window units.
The diagram shows the basic test design.



The tops and bottoms of the units are sealed so that air is trapped between them.

2 (a) During the test, the manufacturer uses the same type of glass and the same initial temperatures either side of the window.
State **two** other factors which must be kept the same to keep this a fair test.

Factor 1 .....

.....

Factor 2 .....

.....

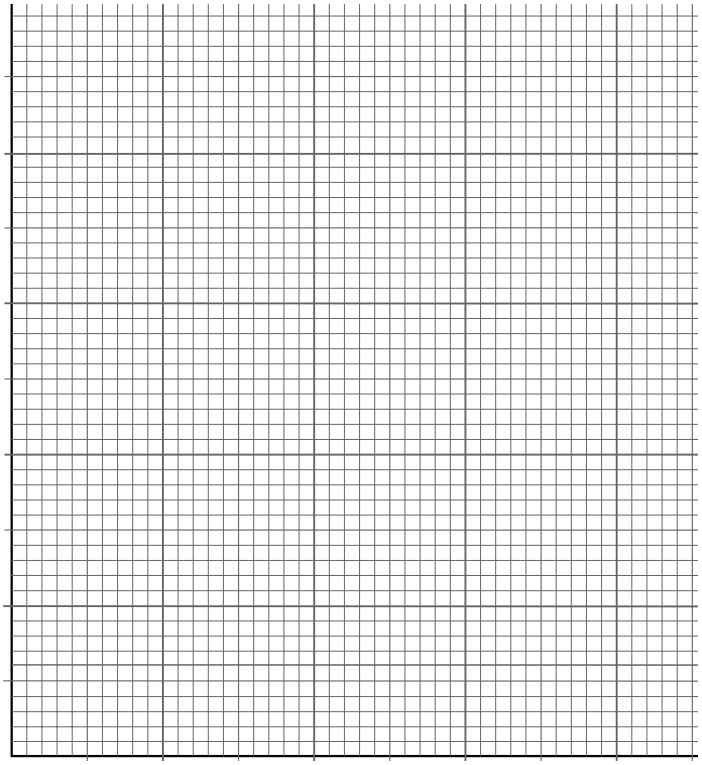
(2 marks)

2 (b) The manufacturer obtains the following results from the tests.

Width of air gap (mm)	**Rate of heat loss through window (W)**
2	4100
3	3650
4	3250
5	2800
6	2400
7	1950

2 (b) (i) Plot these results on the graph below. Draw a line of best fit.

Rate of heat loss (W)



Air gap (mm)

(3 marks)

2 (b) (ii) Describe the trend shown in the graph.

.....

.....

(1 mark)

2 (b) (iii) Use your graph to determine the rate of heat loss for an air gap of 4.6 mm.

.....

(1 mark)

Question 2 continues on the next page

The manufacturer sells double-glazed window units to companies that make window frames. Some of these companies make window frames from wood, others use plastics such as PVC.

2 (c) Suggest **one** advantage and **one** disadvantage of using PVC rather than wood for window frames.

Advantage .....

.....

Disadvantage .....

.....

(2 marks)

2 (d) Apart from window frames, give another use for PVC.

.....

(1 mark)

10

3 It is the job of a materials scientist to select the best material for a particular purpose. The table gives information about the properties of five polymers.

Polymer	Density ($kg\,m^{-3}$)	Tensile strength (MPa)	Maximum operating temperature (^oC)	Dissolves in organic solvents?	
				below 80^oC	above 80^oC
Poly(styrene)	1050	40	65	Yes	Yes
Low density poly(ethene) (LDPE)	920	15	85	No	Yes
High density poly(ethene) (HDPE)	960	29	120	No	Yes
Poly(propene)	900	35	160	No	No
Poly(chloroethene)	1390	60	60	Yes	Yes

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

Polymer .....

.....

Density .....

.....

Tensile strength .....

.....

(3 marks)

3 (b) Why is HDPE more suitable than LDPE for making milk crates?

.....

.....

(1 mark)

3 (c) Use the information in the table to suggest **one** use for LDPE.

.....

.....

(1 mark)

Question 3 continues on the next page

3 (d) (i) Which polymer in the table on **page 7** would be best for making a pipe to carry oil at a temperature of 120°C?

.....

(1 mark)

3 (d) (ii) Give **two** reasons for your choice.

Reason 1 .....

.....

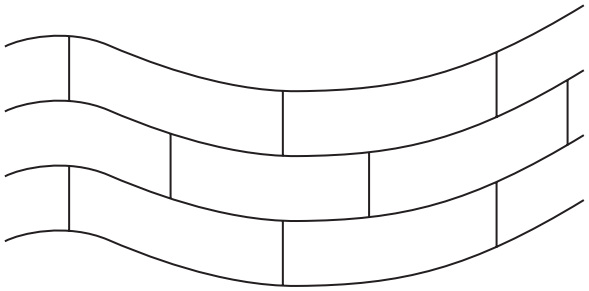
Reason 2 .....

.....

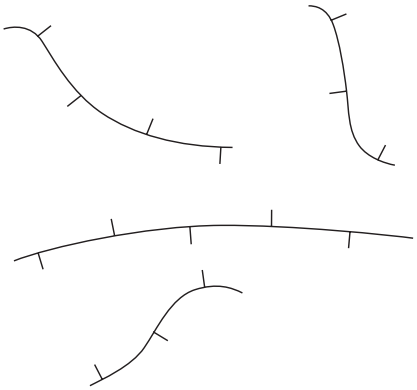
(2 marks)

The diagrams show three different structures of polymers.

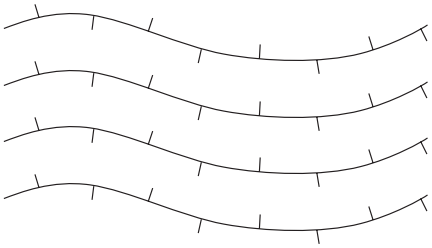
Structure A
Long-chain molecules
cross linked



Structure B
Long-chain molecules
with side chains
irregularly packed



Structure C
Long-chain molecules
with side chains
regularly packed



3 (e) (i) Poly(propene) has a high density and is a thermosoftening polymer. It can be melted and reshaped many times.

Which of the structures **A**, **B** or **C** on **page 8** is poly(propene)?

Structure .....

(1 mark)

3 (e) (ii) Bakelite is a hard, rigid and brittle polymer. It is a thermosetting polymer. Once it has set hard it cannot be reshaped.

Which of the structures **A, B** or **C** on **page 8** is bakelite?

Structure .....

(1 mark)

3 (e) (iii) Explain why bakelite is rigid.

.....

.....

(1 mark)

11

Turn over for the next question

4 Atoms in compounds are joined together by chemical bonds.

It is important that materials scientists know how atoms join together because the type of bond affects the properties and uses of a material.

4 (a) Magnesium oxide, MgO, has a high melting point and is used as a heat-resistant lining in some furnaces.

4 (a) (i) Name the type of chemical bonding in magnesium oxide.

.....

.....

(1 mark)

4 (a) (ii) Explain, in terms of electrons, how this bond is formed.

.....

.....

.....

.....

(2 marks)

4 (b) Ethene, C_2H_4, is a gas at room temperature and is used to make poly(ethene).

4 (b) (i) Name the type of chemical bonding in ethene.

.....

.....

(1 mark)

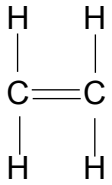
4 (b) (ii) Explain in terms of electrons how this bond is formed.

.....

.....

(1 mark)

4 (c) The structural formula for ethene is shown.



4 (c) (i) What part of the structure of ethene molecules allows them to be used to make poly(ethene)?

.....

.....

(1 mark)

4 (c) (ii) What word is used to describe the simple molecules, like ethene, from which polymers are made?

.....

.....

(1 mark)

4 (c) (iii) By what name is poly(ethene) more commonly known?

.....

(1 mark)

8

Turn over for the next question

5 An electrical power company needs to invest in new pylons and overhead electrical cables to carry electricity to a large, new industrial development.

Engineers employed by the company test four materials, **A**, **B**, **C** and **D,** that might be used for the electrical cables and the pylons.

The table shows the values the engineers obtained for four properties of the tested materials.

Material	**Density ($kg\,m^{-3}$)**	**Tensile strength ($N\,m^{-2}$)**	**Electrical conductivity ($m^{-1}\,\Omega^{-1}$)**	**Thermal conductivity ($W\,m^{-1}\,K^{-1}$)**
A	3.1×10^{3}	0.9×10^{11}	5.7×10^{7}	3.8×10^{2}
B	1.1×10^{3}	5.9×10^{11}	1.1×10^{-8}	1.3×10^{-1}
C	2.0×10^{3}	1.2×10^{9}	3.9×10^{-4}	7.8×10^{-2}
D	1.8×10^{3}	7.9×10^{8}	1.9×10^{-9}	2.3×10^{-2}

5 (a) Give the definition of *thermal conductivity*.

.....

.....

(1 mark)

5 (b) To measure the electrical conductivity of a material, an engineer measures its electrical resistance.

Give **two** other measurements of the material that the engineer must take in order to calculate the electrical conductivity.

Measurement 1 .....

Measurement 2 .....

(2 marks)

5 (c) Using information from the table on **page 12**, which material, **A, B**, **C** or **D**, is most likely to be a metal?
Give **three** reasons for your choice.

Material .....

Reason 1 .....

.....

Reason 2 .....

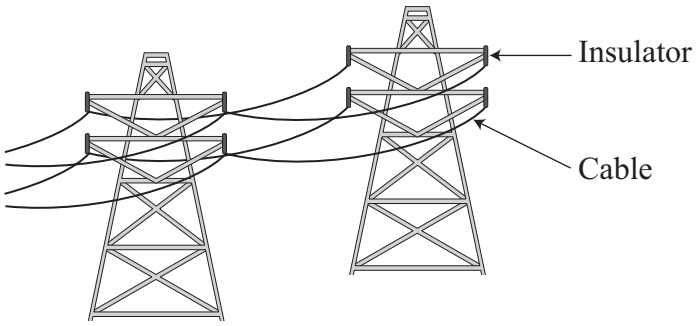
.....

Reason 3 .....

.....

(4 marks)

5 (d) The diagram shows some overhead cables suspended from pylons. The cables are attached to the pylons using insulators.



The insulators are made from a material that must have the following properties:

- low density
- high tensile strength
- low electrical conductivity.

5 (d) (i) Using information from the table on **page 12**, which material, **A, B**, **C** or **D**, would be the most suitable for making the insulators?

Material .....

(1 mark)

Question 5 continues on the next page

5 (d) (ii) Which of the following types of material is the insulator most likely to be made from?

metal
rubber
ceramic
alloy

Material .....

(1 mark)

5 (e) When choosing a material for the overhead cables, the thermal expansivity also needs to be considered.

5 (e) (i) Define *thermal expansivity*.

.....

.....

(1 mark)

5 (e) (ii) Why is thermal expansivity important in this situation?

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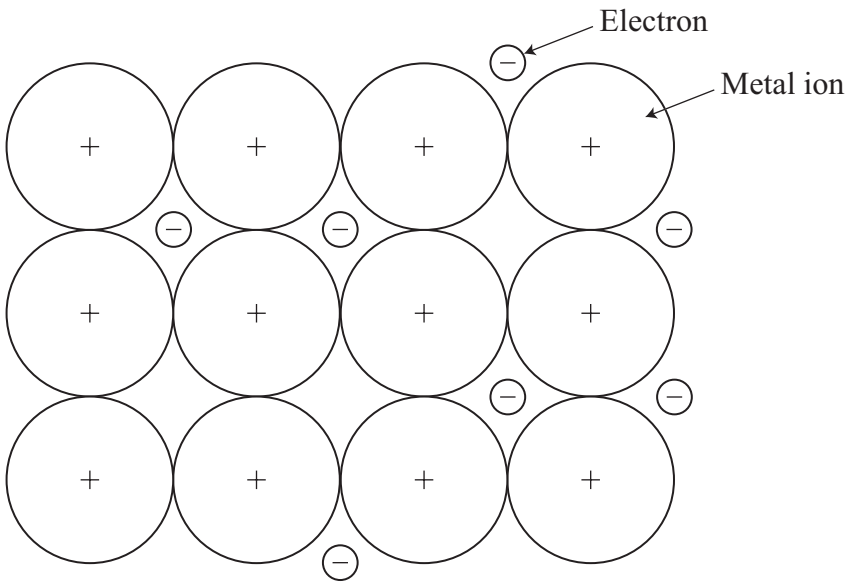
(1 mark)

5 (f) The properties of metals make them suitable to use as electrical cables.
The diagram shows a model of metallic bonding.



Draw lines to connect boxes so that each metal property is linked to the correct reason.

Metal property	Reason
Conducts electricity	Ions and electrons held together by strong attractive forces
High melting point	Electrons can move
Can be made into wires	Ions can slide over each other

(2 marks)

5 (g) Overhead electrical cables are usually made from aluminium alloy.

5 (g) (i) What is the meaning of the term *alloy*?

.....

(1 mark)

5 (g) (ii) Other than cost, suggest a reason why the overhead electrical cables are made from aluminium alloy instead of pure aluminium.

.....

.....

(1 mark)

5 (h) A block of aluminium alloy has a volume of $5 \times 10^{-4} m^3$. The density of the aluminium alloy is $2.7 \times 10^3 kg\ m^{-3}$.

Calculate the mass of the block.

.....

.....

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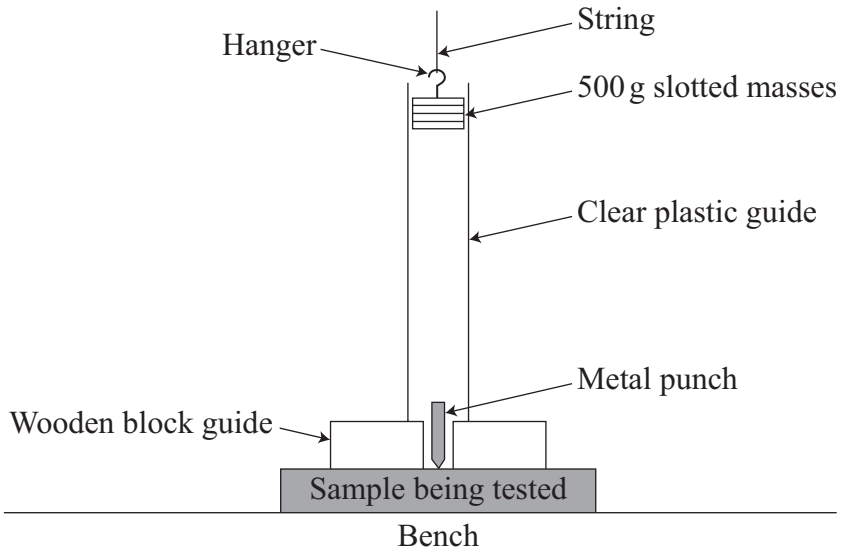
.....

.....

(3 marks)

18

6 The hardness of a material is a measure of how difficult it is to dent or scratch the material. A technician is asked to compare the hardness of three different materials. The diagram shows the apparatus she used.



She also has available

- a metre rule
- a supply of 500 g slotted masses
- vernier callipers (these measure small distances accurately)

6 (a) Describe how she could use the apparatus to compare the hardness of samples of three different materials. Each of the samples has the same dimensions.

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(7 marks)

6 (b) Explain how she would use her results to decide which material was the hardest.

.....

.....

(1 mark)

8

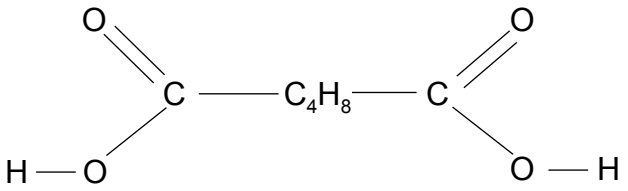
Turn over for the next question

Read this article about nylon and use the information and your own knowledge to answer Question 7.

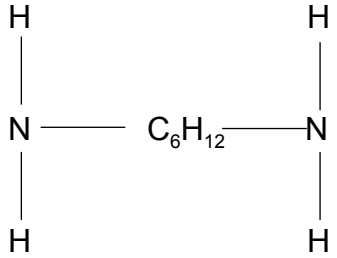
Nylon

Nylon is one of the most commonly used polymers. It was first produced in 1935 and was intended to be a synthetic replacement for silk.

One type of nylon is made by mixing solutions of hexanedioic acid and diaminohexane. The structural formula for each of these compounds is shown below. The type of nylon formed from this reaction is called nylon-6,6.



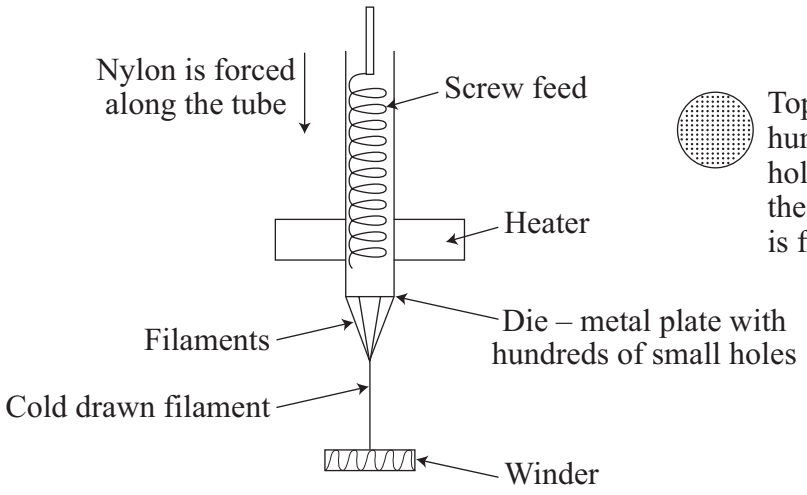
Hexanedioic acid



Diaminohexane

(Molecular formula = $C_6H_{10}O_4$)

Nylon is most commonly used in the form of fibres. Nylon fibres are produced in a process called extrusion. The diagram shows this process.



Top view of die – hundreds of small holes through which the molten nylon is forced.

Nylon granules are fed along the tube. Heaters make the nylon soft as it is forced through the die. Filaments emerge from the die. The filaments are pulled together and cold drawn in a continuous process. The fibre is collected on a winder. The extrusion process relies on the fact that nylon is a thermosoftening plastic (this means that it goes soft when heated but becomes hard again when cooled). The process can be repeated over and over again.

Nylon fibres have many uses including fabrics used to make clothing and footwear, ropes, composites, fishing lines and nets, racquet strings and guitar strings.

Nylon does not absorb water. Clothes made from nylon fibres do not absorb perspiration and allow it to evaporate. The nylon fibres are usually mixed with natural fibres such as wool and cotton. This mixture absorbs water.

7 (a) What is meant by a *synthetic* substance?

.....

.....

(1 mark)

7 (b) What is the molecular formula of diaminohexane?

.....

(1 mark)

7 (c) Look at the structural formulae for hexanedioic acid and diaminohexane. The type of nylon formed from these compounds is called nylon-6,6. Suggest a reason why.

.....

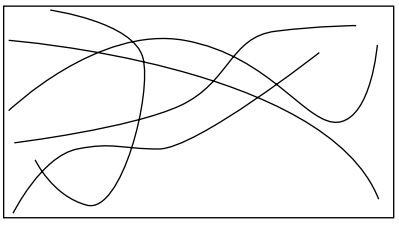
.....

(1 mark)

7 (d) The extrusion process used to produce nylon filaments also uses the process of cold drawing.

7 (d) (i) The diagram in the left-hand box shows the nylon polymer molecules before cold drawing.
Complete the right-hand box to show the arrangement of the nylon polymer molecules after cold drawing.

Before cold drawing



After cold drawing

(1 mark)

7 (d) (ii) State **one** change in the properties of nylon after it has been cold drawn.

.....

.....

(1 mark)

Question 7 continues on the next page

7 (e) Nylon fibre is used in sports shoes. The density of nylon is $1.2\,g\,cm^{-3}$.

7 (e) (i) Give **two** reasons why having a low density makes nylon a suitable material for use in sports shoes.

Reason 1 .....

.....

Reason 2 .....

.....

(2 marks)

7 (e) (ii) Suggest **two** further properties, other than low density, which make nylon a suitable material for use in sports shoes.

Property 1 .....

.....

Property 2 .....

.....

(2 marks)

7 (f) Clothes made from nylon fibres mixed with natural fibres are more comfortable to wear than clothes made from nylon fibres alone. Suggest a reason why.

.....

.....

(1 mark)

7 (g) A materials scientist measured the breaking stress and strain of a nylon fibre.

7 (g) (i) What is meant by the term *stress*?

.....

.....

(1 mark)

7 (g) (ii) What is meant by the term *strain*?

.....

.....

(1 mark)

7 (h) The breaking stress of the nylon fibre was found to be 9×10^{-3} N m^{-2} and the strain was found to be 6×10^{-2}.

7 (h) (i) Why does strain have no units?

.....

.....

(1 mark)

7 (h) (ii) Calculate the value of the Young modulus for the nylon fibre.

.....

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.....

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(3 marks)

7 (h) (iii) Nylon fibre has a low Young modulus value.
What does this tell you about nylon fibre?

.....

.....

(1 mark)

17

END OF QUESTIONS

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