Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

For Examiner's Use

General Certificate of Education
June 2009
Advanced Subsidiary Examination

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

Friday 22 May 2009 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 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			
Question	Mark	Question	Mark
1		5	
2		6	
3		7	
4			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

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ANSWER IN THE SPACES PROVIDED

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

1 Material scientists need to consider the properties of the materials they work with.

The physical properties of a material depend on the structure of the material and the type of bonding between its particles.

The three types of strong bonding between particles are *ionic*, *covalent* and *metallic*.

Draw a line from each description of the structure to the correct type of bonding.

Draw another line from each type of bonding to the physical properties related to it.

Description of the structure	**Type of bonding**	**Physical properties**
Positive and negative particles arranged in a giant lattice.	Ionic	Solids, liquids or gases at room temperature, which do not conduct electricity.
A lattice of positive ions in a 'sea' of free moving electrons.	Covalent	Nearly all are solids at room temperature. Good conductors of electricity.
Separate molecules in which the atoms are held together by shared electrons.	Metallic	All are solids at room temperature, which do not conduct electricity. They have high melting points.

(6 marks)

6

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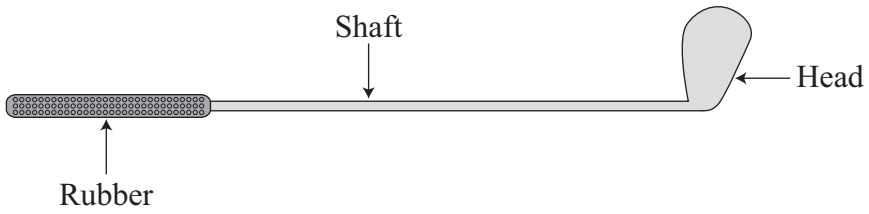
2 A manufacturer of golf clubs decides to use a carbon fibre composite material, rather than steel, to make the shaft of the club. The end of the shaft which the golfer holds is covered with rubber.



2 (a) What is a *composite material*?

.....

.....

(1 mark)

2 (b) Suggest **two** advantages of using a carbon fibre composite material, rather than steel, for making the shaft of the club.

Advantage 1 .....

.....

Advantage 2 .....

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(2 marks)

2 (c) Suggest **one** disadvantage of using a carbon fibre composite material instead of steel for making the shaft of the club.

.....

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(1 mark)

2 (d) Suggest why the rubber at the end of the shaft has lots of small holes, grooves and ridges.

.....

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(1 mark)

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2 (e) Some fishing rods are made from a carbon fibre composite material.

2 (e) (i) Explain why this type of rod has to be used very carefully when fishing close to overhead electrical cables.

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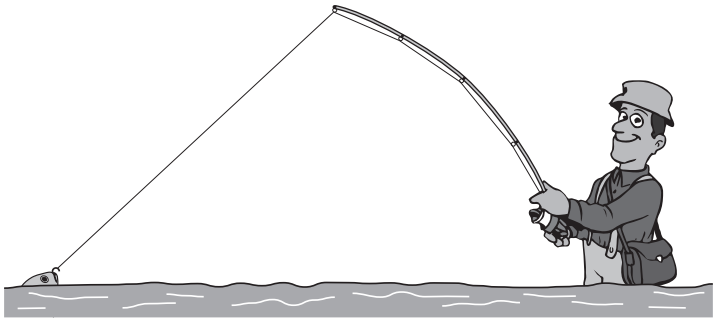
(2 marks)

2 (e) (ii) The diagram shows a fishing rod in use.

Draw an arrow labelled **T** to a part of the rod which is in tension.



(1 mark)

2 (f) Apart from golf clubs and fishing rods, give **one** other example of a piece of sports equipment where a carbon fibre composite material has replaced a conventional material.

.....

.....

(1 mark)

9

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3 The Royal Mint makes the coins used in the United Kingdom. Material scientists are involved in deciding which metals are used to make coins.

3 (a) Many years ago some coins were made from gold and silver. Apart from cost, suggest a reason why these metals are no longer used to make coins.

.....

.....

(1 mark)

3 (b) Modern coins are made from alloys. What is an *alloy*?

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.....

(1 mark)

3 (c) The 'copper' coins (1p and 2p) were once made of bronze (copper, tin and zinc). Since 1992 they have been made of steel coated with a thin layer of copper (copper-plated steel).

3 (c) (i) How does the coating of copper prevent the steel from rusting?

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(1 mark)

3 (c) (ii) Suggest how you could show that a 1p coin made in 2008 is made of copper-plated steel and not bronze.

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(1 mark)

3 (d) Suggest **two** properties that coinage materials should have.

Property 1.....

.....

Property 2.....

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(2 marks)

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3 (e) Alloying alters the properties of metals. Heat treatment has the same effect. Two types of heat treatment are *annealing* and *quenching*.
Read the following statements.

A	Heating the metal until it is red hot followed by controlled cooling. This makes the metal more ductile.
B	Heating the metal until it is red hot followed by controlled cooling. This makes the metal harder.
C	Heating the metal until it is red hot followed by rapid cooling. This makes the metal more ductile.
D	Heating the metal until it is red hot followed by rapid cooling. This makes the metal harder.

3 (e) (i) Which **one** of the statements, **A, B, C** or **D** is the correct description of annealing?

Statement ..... *(1 mark)*

3 (e) (ii) Which **one** of the statements, **A, B, C** or **D**, is the correct description of quenching?

Statement ..... *(1 mark)*

3 (e) (iii) What is the name of the process which involves quenching followed by annealing at a lower temperature?

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(1 mark)

9

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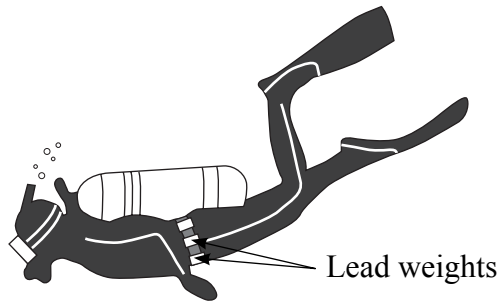
4 Lead is used to make weights used by scuba divers.



4 (a) One reason why lead is used to make diving weights is its high density.
Suggest another reason.

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(1 mark)

4 (b) Describe how you would determine the density of an irregular shaped lump of lead.
You may use diagrams to help your description.

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(5 marks)

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4 (c) A lump of metal has a mass of 3500 kg and a volume of 0.31 m^3. Calculate the density of this metal. Give the correct unit in your answer.

.....

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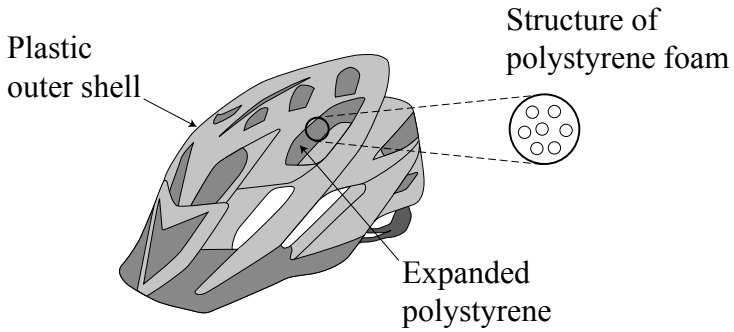
.....

(3 marks)

4 (d) Expanded polystyrene (polystyrene foam) has a very low density. It is made by blowing air into softened plastic.
Cycle helmets help protect a cyclist's head in an accident. The inner part of a cycle helmet is made of expanded polystyrene.



4 (d) (i) What happens to the structure of the foam that helps reduce injury to the cyclist's head during an impact?

.....

.....

(1 mark)

4 (d) (ii) Other than in safety applications, give **one** use for expanded polystyrene.

.....

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(1 mark)

4 (e) The outer part of a cycle helmet is made of a plastic which is tough, rigid and smooth. If a cyclist's head hits the road, the smooth outer surface of the helmet causes it to skid across the road. Suggest why this helps reduce injury to the cyclist's head.

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(1 marks)

Turn over ▶

12

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5 Plastic carrier bags are made from polymers.

5 (a) (i) What is a *polymer*?

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.....

(1 mark)

5 (a) (ii) Give **two** disadvantages of the widespread use of polymers.

Disadvantage 1 .....

.....

Disadvantage 2 .....

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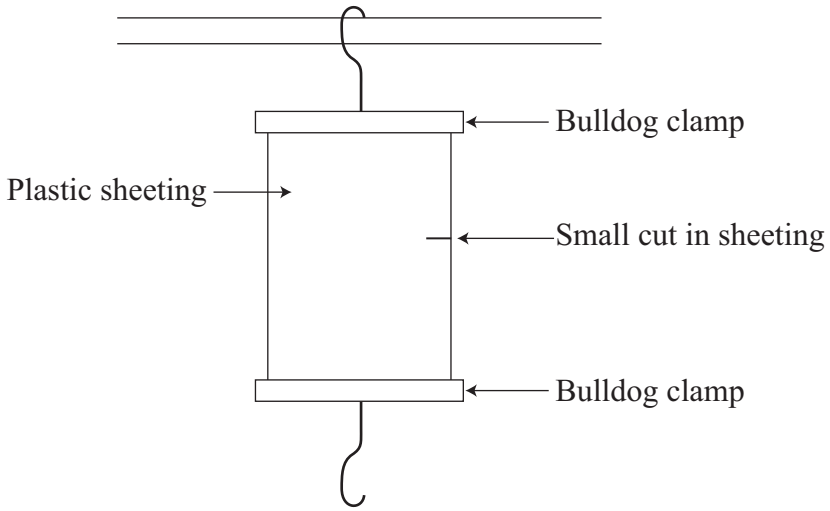
(2 marks)

5 (b) A manufacturer of plastic carrier bags asks a technician to test different samples of plastic sheeting to see which one tears the most easily. The diagram shows the apparatus that she used.



The technician also has available a mass holder and several separate 100 g masses.

100 g
mass hanger

100 g
slotted masses

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5 (b) (i) The technician has samples of three different types of plastic sheeting to test. They all have the same width and thickness.
Describe how she could use the equipment to find the mass required to tear each of the three plastic samples.

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(6 marks)

5 (b) (ii) How would she ensure that her experiment was a fair test?

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(2 marks)

5 (b) (iii) How would she ensure that her results were reliable?

.....

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(1 mark)

Question 5 continues on the next page

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5 (b) (iv) How would she use her results to decide which plastic sheet tears most easily?

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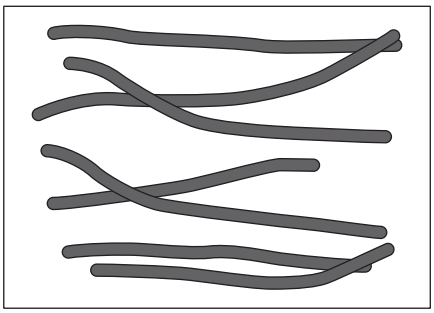
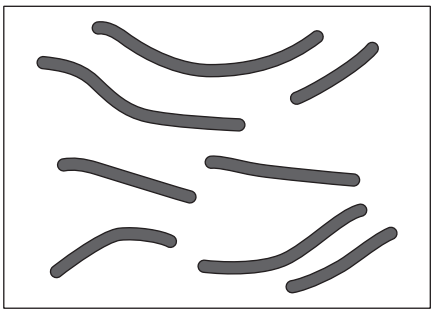
(1 mark)

5 (c) The diagrams show how the polymer molecules are arranged in two different plastics, **A** and **B**.

Plastic A



Plastic B



5 (c) (i) Which plastic would tear most easily? Give a reason for your answer.

Plastic .....

Reason .....

.....

(1 mark)

5 (c) (ii) Apart from how easily it tears, give **one** other difference in properties between plastic **A** and plastic **B**.

.....

.....

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(2 marks)

5 (c) (iii) Suggest **one** way, other than changing the chain length, that polymer molecules in a plastic could be altered to make the plastic easier to tear.

.....

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(1 mark)

17

Turn over for the next question

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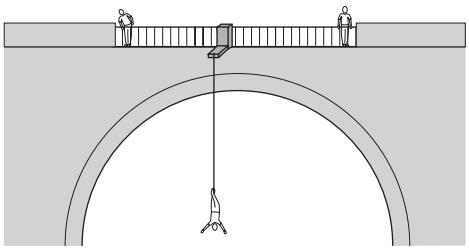
6 A manufacturer of the cords used in bungee jumping is testing a material to see if it is suitable for inclusion in the cords.

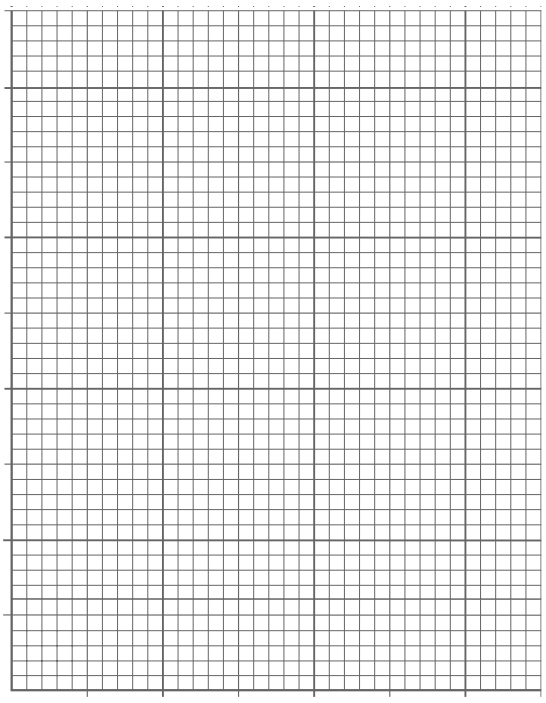


A technician measures the extension of the new material when different forces are applied. The table shows his results.

Force (N)	0	10	20	30	40	50	60
Extension (mm)	0	7	14	21	28	35	42

6 (a) Plot the data on the grid.
Plot force on the *x*-axis and extension on the *y*-axis.
Label the axes, add appropriate units and draw a line of best fit.

(4 marks)



6 (b) (i) Name the law the material is obeying.

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(1 marks)

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6 (b) (ii) Assuming that the material continues to obey this law for forces up to 100 N, calculate the extension produced by a force of 85 N.

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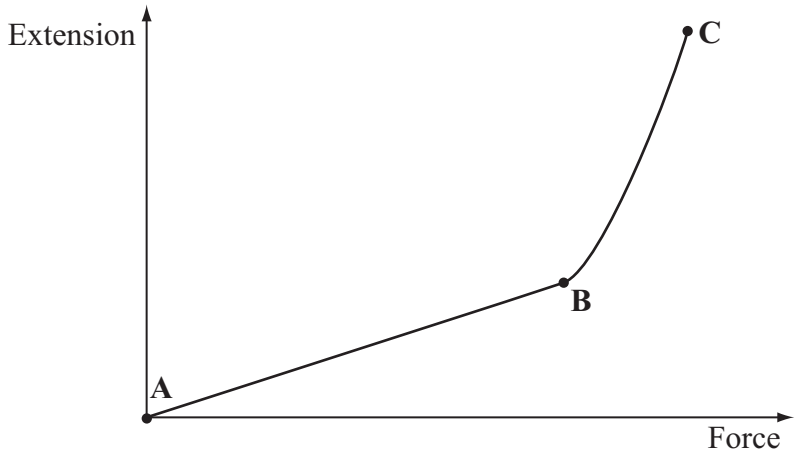
Answer = ...mm

(2 marks)

6 (c) The sketch shows the graph of extension against force for a different material.



6 (c) (i) On the sketch graph draw an arrow labelled **P** to a point at which the material is undergoing plastic deformation. *(1 mark)*

6 (c) (ii) What name is given to point **B** on the sketch graph?

.....

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(1 mark)

Question 6 continues on the next page

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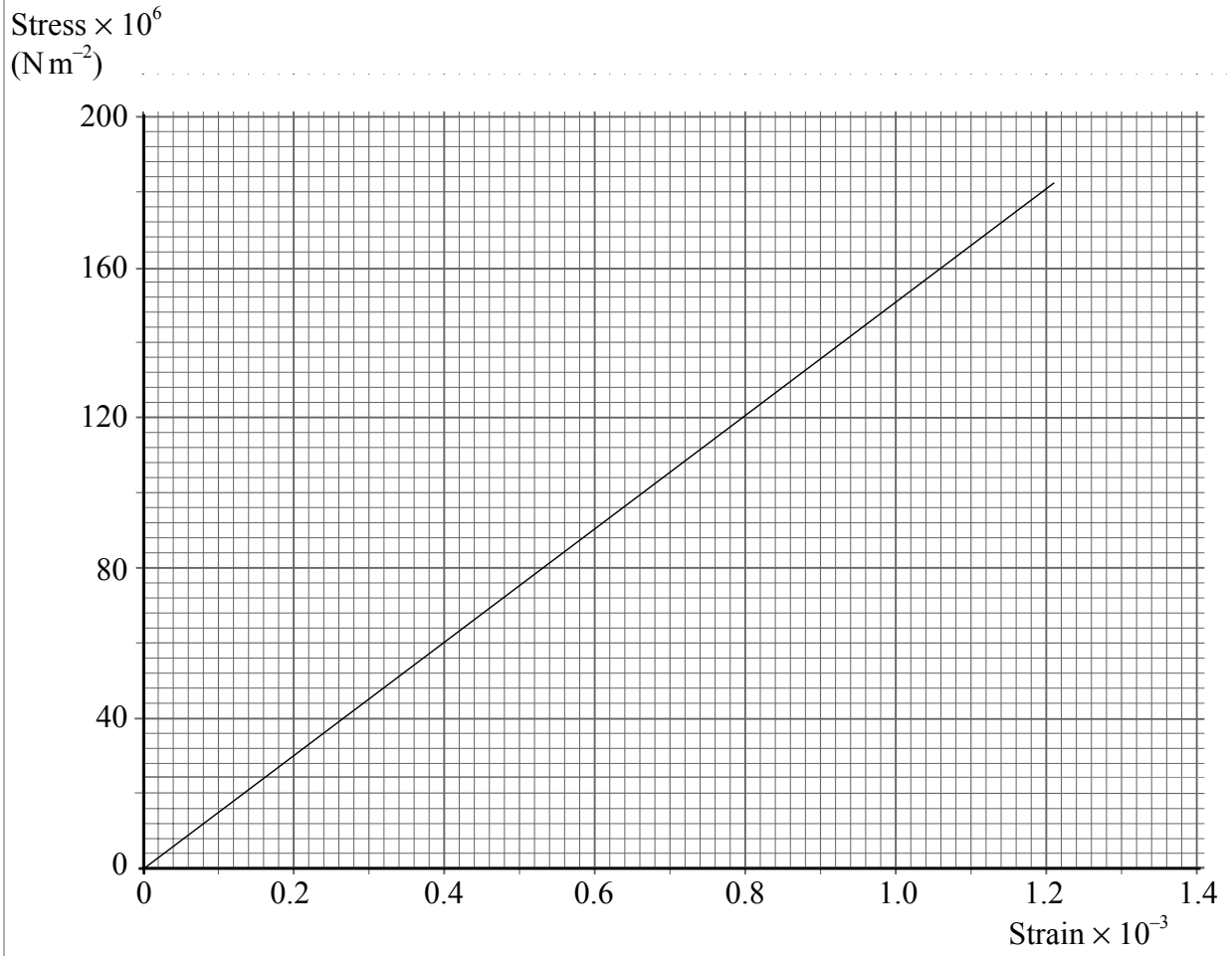
6 (d) The graph of stress against strain shown below is for another material that was tested for inclusion in the bungee cords.



The material had a cross-sectional area of 1.5×10^{-5} m^2.

6 (d) (i) Calculate the force applied to the material when the strain is 0.4×10^{-3}.

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Answer =.....N

(3 marks)

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6 (d) (ii) Calculate the Young modulus of the material. Give the correct unit in your answer.

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(3 marks)

6 (e) The manufacturer of bungee cords must be able to guarantee the maximum stretched length of cords they supply. Suggest a reason why this is important.

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(1 mark)

16

Turn over for the next question

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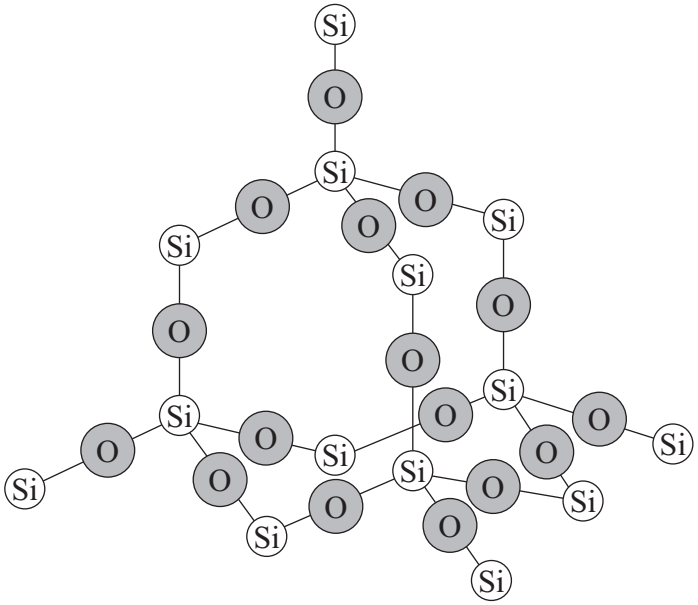
7 Read this article about glass and use the information and your own knowledge to answer Question 7.

Glass

Glass is a mixture of calcium silicate, $CaSiO_3$, and sodium silicate, Na_2SiO_3. It is made by heating sand (silicon dioxide) with limestone (calcium carbonate) and soda (sodium carbonate) to a very high temperature.

The structure of glass resembles that of silicon dioxide, SiO_2, which is a crystalline substance with a macromolecular structure. The diagram shows part of the structure of silicon dioxide.



However, in glass many of the Si–O bonds have been broken, and the structure is much less regular than that of silicon dioxide. X-ray analysis shows that glass does not have the orderly packing of atoms found in other solids.

Window glass is elastic but it is also brittle. In certain cases, building regulations often specify that toughened glass must be used. Toughened glass is obtained by heat treating ordinary glass.

Though clear window glass is transparent, it only transmits about 80% of the light that hits it. The rest is either reflected or is absorbed by the glass. Frosted glass has an irregular surface. The light rays are jumbled as they pass through and so a clear image is not seen. It is said to be translucent.

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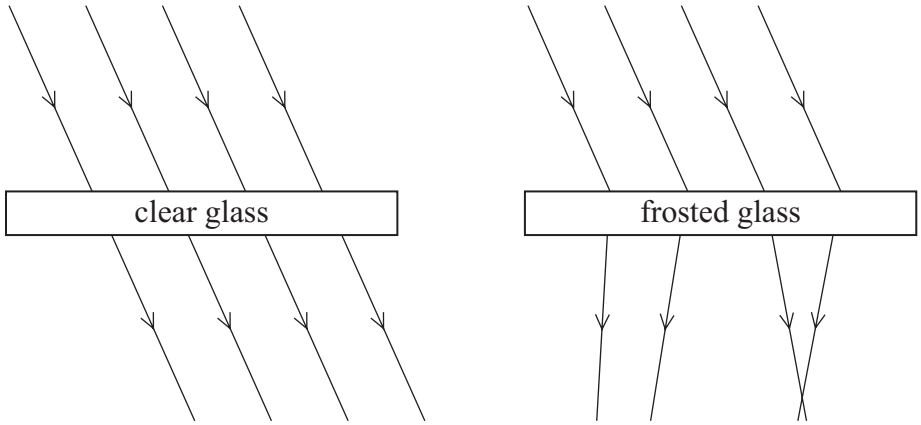

Light is not scattered Light is scattered

Recently, self-cleaning glass has been produced. On the outer surface, it has a very thin coating of titanium oxide. When dirt lands on the window, this coating breaks down the dirt using ultraviolet energy from the sun. Rain then washes the dirt off.

Manufacturers of spectacle lenses used to use glass but now prefer to use a clear plastic called polycarbonate. There are two reasons for this. Polycarbonate lenses are a lot lighter than glass lenses, but also they have a much higher refractive index. This means polycarbonate lenses will bend light more than glass lenses, so they can be much thinner than glass lenses.

7 (a) (i) What is the chemical name for sand?

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(1 mark)

7 (a) (ii) What type of bonding is present in sand?

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(1 mark)

7 (b) Silicon dioxide has a macromolecular structure. Explain the meaning of the word *macromolecular*.

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(1 mark)

Question 7 continues on the next page

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7 (c) What word describes the structure of glass?

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.....

(1 mark)

7 (d) In terms of light, what is the difference between a *transparent* substance and a *translucent* substance?

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(1 mark)

7 (e) Where might frosted glass be used in a house?

.....

.....

(1 mark)

7 (f) Give **one** property difference between ordinary glass and toughened glass.

.....

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(1 mark)

7 (g) Suggest a use for toughened glass in a building.

.....

.....

(1 mark)

7 (h) Self-cleaning glass is very expensive. Give an example of where self-cleaning glass might be used where the cost can be justified.

.....

.....

(1 mark)

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7 (i) Apart from density and refractive index, suggest **two** other properties of polycarbonate that make it a better choice than glass for making spectacle lenses.

Property 1.....

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Property 2.....

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(2 marks)

11

END OF QUESTIONS

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