AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

AS
APPLIED SCIENCE

Unit 5 Choosing and Using Materials

Wednesday 18 May 2016 Afternoon Time allowed: 1 hour 30 minutes

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

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 Some commonly used materials are listed below.

bronze	**nylon**	**stainless steel**
zinc	**glass-reinforced plastic (GRP)**	**perspex**
brick	**concrete**	**glass**

1 (a) (i) Select **one** example of a polymer from the list.

[1 mark]

_____

1 (a) (ii) Select **one** example of a ceramic from the list.

[1 mark]

_____

1 (a) (iii) What is meant by the term **alloy**?
Select **one** example of an alloy from the list.

[2 marks]

Meaning _____

_____

Example _____

1 (a) (iv) What is meant by the term **composite**?
Select **one** example of a composite material from the list.

[2 marks]

Meaning _____

_____

Example _____

1 (a) (v) State **one** benefit of a composite material.

[1 mark]

_____

_____

1 (a) (vi) Several of the materials in the list are synthetic.

What is meant by the term **synthetic**?

[1 mark]

_____

_____

1 (b) Glass is an amorphous material.

What is meant by the term **amorphous**?

[1 mark]

_____

_____

1 (c) Stainless steel is much more resistant to corrosion than other steels. Stainless steel is also strong and attractive to look at.

Suggest **one** reason why stainless steel is **not** used more widely.

[1 mark]

_____

_____

10

Turn over for the next question

2 Tensile strength and compressive strength are important mechanical properties of materials.

2 (a) (i) Tick (✓) **one** box in each row of **Table 1** to show whether the items listed need a high tensile strength or a high compressive strength.

[2 marks]

Table 1

Item	High tensile strength	High compressive strength
A tent rope		
A building brick		
A concrete paving stone		
A metal anchor chain		

2 (a) (ii) Which word describes a material that has good tensile strength **and** good compressive strength?

Circle the correct answer.

[1 mark]

hard **ductile** **dense** **flexible** **brittle**

2 (b) A student does an experiment to find out if the ultimate tensile strength of a wire is affected by its cross-sectional area.

He measures the breaking forces of wires of the same length and made from the same material, but with different cross-sectional areas.

Table 2 shows his results.

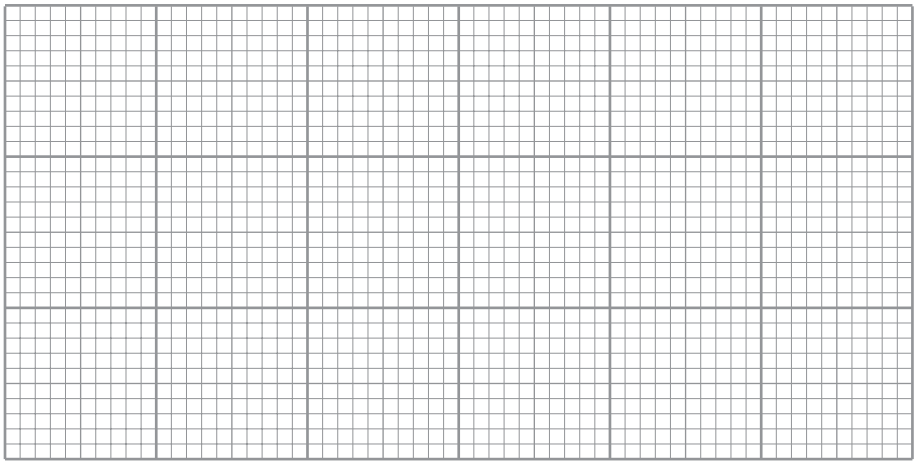
Table 2

Cross-sectional area (mm^2)	1.5	2	4	5	7	8	9.8
Breaking force (N)	0.75	1	2	2.5	3.5	4	4.9

2 (b) (i) Plot the data in **Table 2** onto the grid below.

Plot cross-sectional area on the *x*-axis and breaking force on the *y*-axis.
Label the axes, add appropriate units and draw a line of best fit.

[3 marks]



2 (b) (ii) Use your graph to find the breaking force for a wire of cross-sectional area 3.6 mm^2.

[1 mark]

Breaking force = _____ N

2 (b) (iii) State how the tensile strength of a material depends on its cross-sectional area.
How does your graph show this?

[2 marks]

_____

_____

_____

_____

2 (c) Strength is a mechanical property.

Name **one** other mechanical property.

[1 mark]

_____

10

3 **Table 3** shows information about some properties of four materials, **A**, **B**, **C** and **D**.

Table 3

Material	Thermal conductivity ($W\ m^{-1}\ K^{-1}$)	Electrical conductivity ($m^{-1}\ \Omega^{-1}$)	Tensile strength ($N\ m^{-2}$)	Density ($kg\ m^{-3}$)
A	3.6×10^{2}	5.2×10^{7}	0.8×10^{11}	3.2×10^{3}
B	1.5×10^{-1}	1.3×10^{-8}	5.3×10^{11}	1.2×10^{3}
C	6.9×10^{-2}	3.4×10^{-4}	1.4×10^{9}	2.1×10^{3}
D	1.9×10^{-3}	1.6×10^{-9}	7.3×10^{8}	1.7×10^{3}

3 (a) (i) Using information from **Table 3**, state which material, **A**, **B**, **C** or **D**, is most likely to be a metal.
Give **two** reasons for your choice.

[3 marks]

Material _____

Reason 1 _____

_____

Reason 2 _____

_____

3 (a) (ii) Using information from **Table 3**, state which material, **A**, **B**, **C** or **D**, is most likely to be a ceramic.
Give **two** reasons for your choice.

[3 marks]

Material _____

Reason 1 _____

_____

Reason 2 _____

_____

3 (b) Give the definition of **thermal conductivity**.

[1 mark]

_____

_____

3 (c) Electrical resistance has to be measured to calculate the electrical conductivity of a material.

Give **two** other measurements that must be made to calculate a material's electrical conductivity.

[2 marks]

1 _____

2 _____

3 (d) (i) Give the definition of **density**.

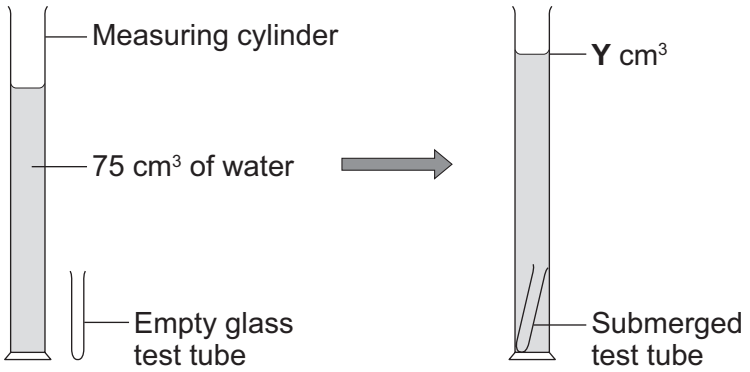
[1 mark]

_____

_____

3 (d) (ii) **Figure 1** shows the apparatus used by a technician to work out the density of test-tube glass.

Figure 1



The measuring cylinder initially contains 75 cm^3 of water.
The glass test tube has a mass of 1.61×10^{-2} kg.
Using the apparatus shown in **Figure 1** the technician calculated the density of the test-tube glass to be 2.30×10^3 kg m^{-3}.

Calculate the volume **Y** shown on the measuring cylinder in **Figure 1**.

[3 marks]

_____

_____

_____

_____

Volume **Y** = _____ cm^3

13

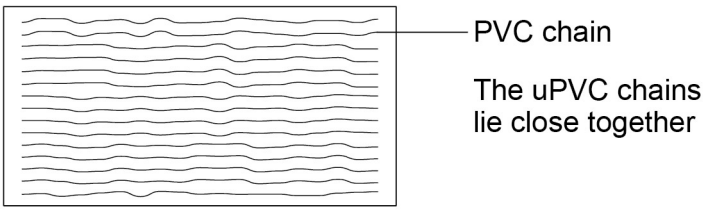
4 **Read the following article about plasticisers.**
Use the information in the article and your own knowledge to answer the questions that follow the article.

Plasticisers

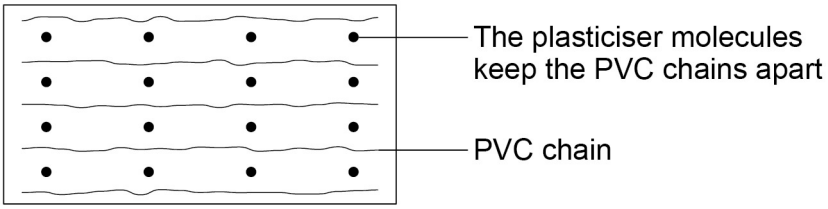
Plasticisers are added to polymers such as polyvinylchloride (PVC) to change the properties of the polymers. PVC is used for making window frames and guttering, which need to be durable and rigid. PVC is also used to make children's toys, which need to be softer and more flexible than window frames and guttering. Plasticiser is added to make PVC softer and more flexible. The small molecules of the plasticiser fit between the polymer chains, as shown in **Figure 2**.

Figure 2

Unplasticised PVC (uPVC)



Plasticised PVC



Several research studies have looked at the safety of one group of plasticisers called phthalates. As a result, the use of phthalates in making toys for babies and young children is now banned in Europe and the USA, but they are still used in furniture and packaging. Blood and urine tests show that low levels of phthalates are present in the bodies of over 90% of people in Europe and the USA.

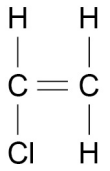
Phthalates in plastics slowly diffuse to the surface of the plastic and escape into the environment. This causes a possible health risk and also means that plasticised PVC goods gradually deteriorate.

Scientists have recently discovered a way to stop phthalates escaping from PVC. They have found a way to chemically attach the phthalates to the PVC polymer chains. Once attached, the phthalate molecules cannot diffuse through the polymer structure and escape.

4 (a) PVC, or polyvinylchloride, is more correctly known as poly(chloroethene). It is a polymer made from the monomer chloroethene.

Figure 3 shows the structure of a chloroethene molecule.

Figure 3



4 (a) (i) Name the type of bonding in the chloroethene molecule.

[1 mark]

_____

4 (a) (ii) Describe this type of bonding.

[1 mark]

_____

_____

4 (a) (iii) What part of the structure of chloroethene molecules allows them to be polymerised?

[1 mark]

_____

4 (b) Plasticisers change the properties of PVC.

State **two** ways in which plasticisers change the properties of PVC.

[1 mark]

1 _____

2 _____

Question 4 continues on the next page

4 (c) Tests have shown that plasticisers are found in most people.

Suggest how plasticisers enter people's bodies.

[2 marks]

4 (d) Plasticisers change the properties of polymers such as PVC.

Use ideas about forces and energy to explain how plasticisers change the properties of a polymer.

[3 marks]

4 (e) Products made of plasticised PVC become less flexible over time.

Explain why this happens.

[2 marks]

11

5 This question is about materials used to make cutting tools such as drill bits.

5 (a) Metals have a crystalline structure.

What is meant by **crystalline structure**?

[1 mark]

5 (b) Drill bits can be made from steel alloy.
Steel alloy is less ductile than pure iron.

5 (b) (i) State the meaning of the term **ductile**.

[1 mark]

5 (b) (ii) Explain why steel alloy is less ductile than pure iron.

You may use diagrams to help explain your answer.

[3 marks]

Question 5 continues on the next page

5 (c) (i) State what is meant by **hardness**.

[1 mark]

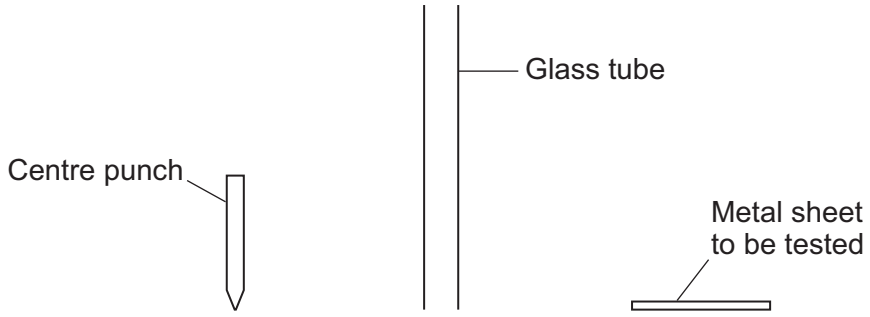
5 (c) (ii) Diamond is much harder than steel.

Why does this make a diamond-coated steel drill bit better than a steel drill bit?

[1 mark]

5 (d) **Figure 4** shows some apparatus that can be used to do a simple test of hardness.

Figure 4



Describe how you would use the apparatus shown in **Figure 4** to compare the hardness of two different metals.

State clearly:

- the measurements you would need to make
- the instruments you would use to make these measurements
- how you would make sure your results were valid and repeatable
- how your results would help you to decide which metal was the harder.

[8 marks]

Extra space (if needed) _____

15

6 When substances are heated, they expand. Engineers need to allow for expansion when building large structures.

The expansion of different substances can be compared by looking at their coefficients of linear expansion.
A coefficient of linear expansion can be calculated using the formula:

$$\text{coefficient of linear expansion} = \frac{\text{increase in length}}{\text{original length} \times \text{rise in temperature}}$$

6 (a) **Table 4** shows the coefficients of linear expansion for different materials.

Table 4

Material	**Coefficient of linear expansion ($^{\circ}C^{-1}$)**
Aluminium	0.00003
Concrete	0.00001
Platinum	0.000009
Copper	0.00002
Glass	0.000009
Steel	0.00001

Use the information in **Table 4** to answer the following questions.

6 (a) (i) An aluminium rod, a copper rod and a steel rod have the same length at room temperature.

Which rod will be the longest at 300 °C?

[1 mark]

_____

6 (a) (ii) Why is steel a suitable material for reinforcing concrete?

[1 mark]

_____

_____

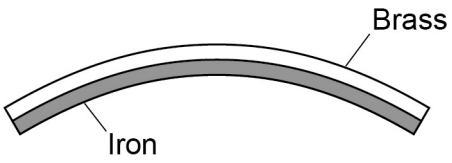
6 (a) (iii) Calculate the increase in length of a 0.5 m copper pipe when it is heated from 15 °C to 85 °C. Give the correct unit in your answer.

[3 marks]

Increase in length = _____

6 (b) A bimetallic strip made of brass and iron is straight at room temperature. **Figure 5** shows the strip after it has been heated.

Figure 5



6 (b) (i) Which material, brass or iron, has the larger coefficient of linear expansion? Give **two** reasons for your answer.

[2 marks]

Material _____

Reason 1 _____

Reason 2 _____

6 (b) (ii) Draw a **labelled** diagram to show the same bimetallic strip after it has been cooled to below room temperature in a freezer.

[1 mark]

8

7 A crane uses steel cables to lift heavy objects, as shown in **Figure 6**.

Figure 6

7 (a) The steel cables in a crane need to be strong.

Name **one** other property of steel that is important in this application and explain why this property is important.

[2 marks]

Property _____

Explanation _____

_____

7 (b) (i) Give the definition of **strain**.

[1 mark]

_____

_____

7 (b) (ii) Give the definition of **stress**.

[1 mark]

_____

_____

7 (b) (iii) How can the values of strain and stress be used to calculate the Young modulus of a material?

[1 mark]

_____

_____

7 (c) When the tension in a steel cable is 5.4×10^4 N the stress is 1.1×10^8 Pa.

Calculate the cross-sectional area of the steel cable. Give the correct unit in your answer.

[3 marks]

_____

_____

_____

_____

_____

Cross-sectional area = _____

Question 7 continues on the next page

7 (d) (i) Calculate the strain in a steel cable at a stress of 1.1×10^8 Pa.
The Young modulus of steel is 2.1×10^{11} Pa.

[2 marks]

Strain = _____

7 (d) (ii) The total length of the steel cable is 650 m.

Calculate the extension of the steel cable when the stress is 1.1×10^8 Pa.

[2 marks]

Extension = _____ m

7 (e) Suggest why the maximum stress in a metal cable is limited to about one-third of its yield stress.

[1 mark]

13

END OF QUESTIONS

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