Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2019

Centre Number

Candidate Number

Life and Health Sciences

Assessment Unit AS 5
assessing

Material Science

SZ051

[SZ051]
FRIDAY 24 MAY, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all eight** questions.
Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 75.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
You may use an electronic calculator.
Quality of written communication will be assessed in question **7(a)**.

For Examiner's use only	
Question Number	**Marks**
1	
2	
3	
4	
5	
6	
7	
8	
Total Marks	

Examiner Only	
Marks	Remark

1 **(a)** Materials are selected for a particular use depending on their physical properties. Define the following properties:

(i) tensile strength

_____

_____ [1]

(ii) malleability

_____

_____ [1]

(b) **Fig. 1.1** represents a stress–strain graph for two different materials, X and Y. Both materials are stretched until they break.

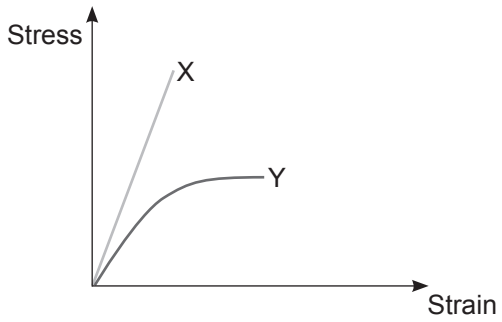

Fig. 1.1

(i) Which material, X or Y, is more ductile?
With reference to the graph, explain your answer.

Material: _____

Explanation: _____

_____ [1]

(ii) Which material, X or Y, has a greater value of Young modulus?
With reference to the graph, explain your answer.

Material: _____

Explanation: _____ [1]

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(Questions continue overleaf)

Examiner Only	
Marks	Remark

2 The table below shows a set of results for an experiment using a piece of metallic wire of length 1.2 m and diameter 1.8 mm.

Tension, T /N	Extension, x /mm
0	0.00
100	0.18
200	0.42
300	0.60
400	0.82
500	1.00
600	1.24

(a) Using the grid on the following page, plot a graph of tension against extension.

Label the horizontal axis and select a suitable scale.

Draw the best-fit straight line. [5]

(b) Find the gradient of the graph, in $\mathbf{Nm^{-1}}$.

You are advised to show your working.

_____ Nm^{-1} [3]

(c) Determine the cross-sectional area of the metallic wire, in m^2.

You are advised to show your working.

Cross-sectional area: _____ m^2 [2]

(d) Calculate the Young modulus, in Pa, for this metal.

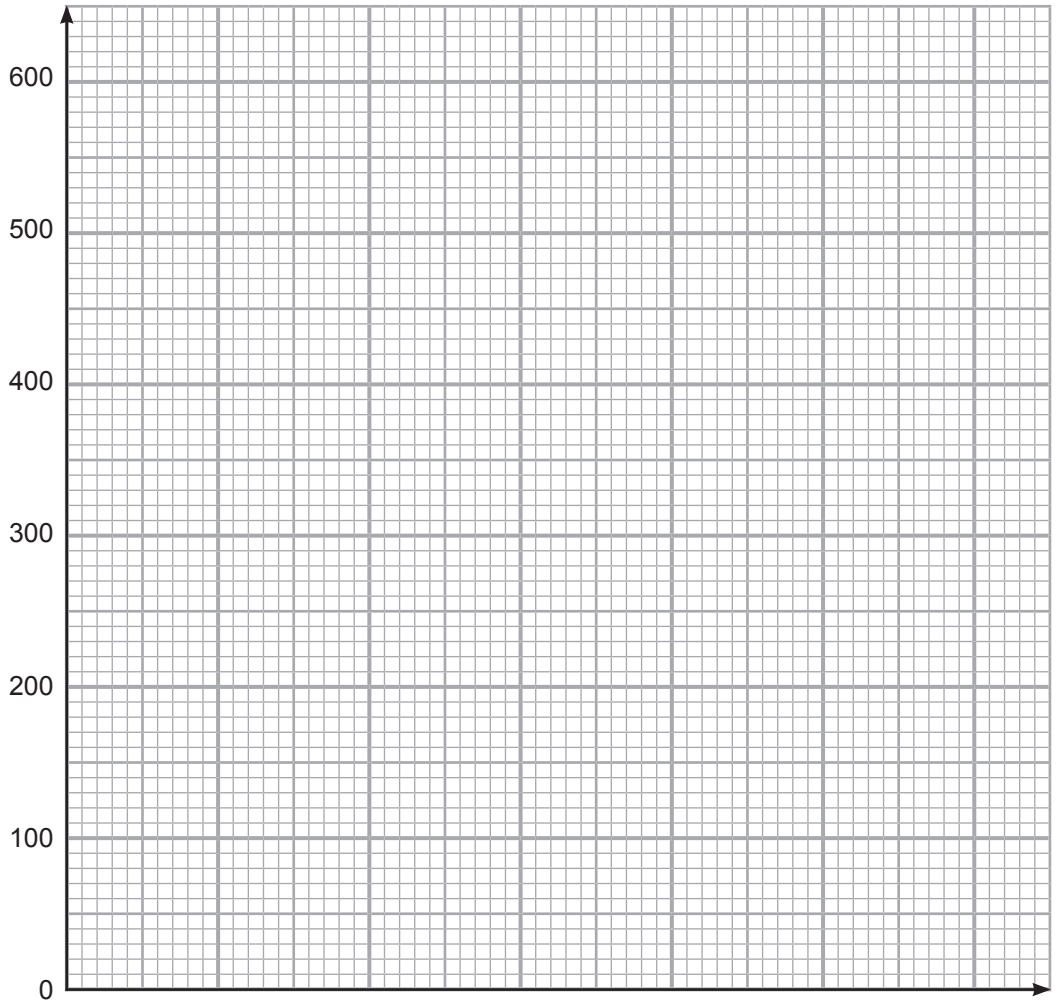
You are advised to show your working.

Young modulus: _____ Pa [3]

Examiner Only

Marks	Remark

Tension, T /N



Examiner Only	
Marks	Remark

3 Carbon nanotubes have a number of potential uses in healthcare.

(a) (i) Describe the structure of a carbon nanotube.

_____

_____ [2]

(ii) State **two** other uses of nanotubes in healthcare.

1. _____

2. _____ [2]

(iii) Suggest **two** physical properties of nanotubes which make them suitable for the uses stated in your answer to **(a)(ii)**.

_____

_____

_____

_____ [2]

Examiner Only	
Marks	Remark

(b) Silicon (Si_{14}^{28}) is an excellent semiconductor material.

How many electrons are in the outer shell of a silicon atom?

_____ [1]

(c) In a silicon lattice, all silicon atoms are bonded to neighbouring atoms and there are no free electrons. What would this mean in terms of the electrical conductivity of a silicon crystal at low temperatures?

_____ [1]

Doping is the name given to the process of adding a controlled quantity of impurity to pure silicon.

Doping can produce two types of silicon – n-type silicon and p-type silicon.

(d) **(i)** Describe, in terms of electrons, the difference between n-type and p-type silicon.

_____

_____ [2]

(ii) What would this mean in terms of the conductivity of doped silicon compared to undoped silicon?

_____ [1]

(e) Holes are created in semiconductors and insulators when doped with p-type materials.

Is the charge of a hole positive, negative or neutral?

_____ [1]

Examiner Only	
Marks	Remark

4 Kitchen cookware can be made of ceramic materials.

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Fig. 4.1

(a) List **two** important characteristics of ceramic which make it suitable for this purpose.

_____

_____ [2]

(b) Polymers such as polycarbonate can be used for spectacle lenses. An important property of polymeric materials for this use is transparency.

List **two** advantages of using transparent polymeric materials instead of glass for spectacle lenses.

1. _____

2. _____ [2]

Examiner Only	
Marks	Remark

5 **(a)** Describe the Bohr model of the atom in terms of the names, locations and charges of the particles involved.

_____

_____

_____ [3]

(b) Plastics are divided into the two categories of thermoplastics and thermosets (thermosetting plastics), with each type having different properties.

(i) What is the difference in microscopic structure between thermoplastics and thermosets?

Thermoplastics: _____

_____

Thermosets: _____

_____ [2]

(ii) State one property for each of the following:

Thermoplastics

_____

Thermosets

_____ [2]

(iii) Complete the table below by placing one tick in the correct box for each use.

Use	Thermoplastic	Thermoset
Electrical insulation		
Plastic bottle		

[2]

Examiner Only	
Marks	Remark

6 **(a)** What is an alloy?

_____

_____ [2]

(b) The table below shows some main constituent materials and some alloys with a relevant common use.

Complete the table by filling in the empty boxes.

Main Constituent Materials	Alloy	Common Use
	Brass	
Iron & Chromium		Saucepans
	Nichrome	
Iron & Carbon		Construction

[6]

Examiner Only

Marks	Remark

(c) **Fig. 6.1** shows the mechanical movement of a wristwatch. Its movement has two important components: a balance wheel and a hairspring.
The accuracy of a watch is influenced by changes in temperature. An increase in temperature produces a slight increase in the diameter of the balance wheel, which causes the wheel to oscillate more slowly and the watch to lose time.
Inaccuracies may be reduced by using a low-expansion alloy for the balance wheel.

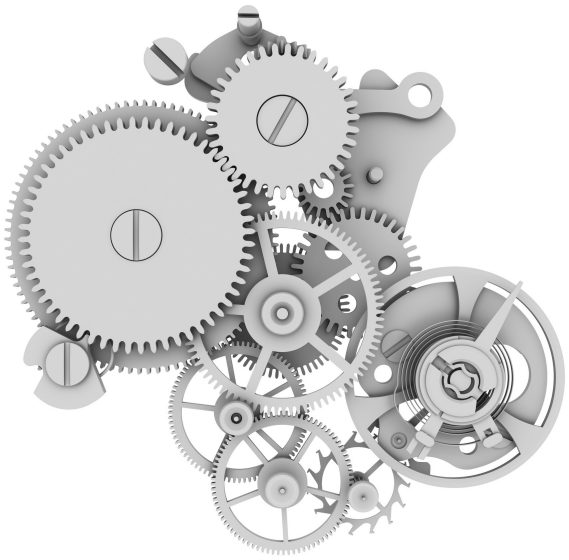

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Fig. 6.1

The coefficient of thermal expansion is the fractional increase in the length when the temperature rises by 1 °C.

(i) From the table below, choose the best alloy for the balance wheel and explain your answer.

Low Expansion Alloy	Coefficient of Thermal Expansion / $°C^{-1}$	Cost / $£kg^{-1}$	Density / gcm^{-3}
Invar	1.6×10^{-6}	36.00	8.05
Super Invar	7.2×10^{-7}	40.00	8.15
Kovar	5.1×10^{-6}	42.00	8.36

Choice of alloy _____

Reason for your choice.

_____

_____ [2]

(ii) What other property, not shown in the table on page 11, should be considered when choosing the best alloy for the balance wheel?

_____ [1]

(d) The hairspring is a flat spiral spring.

It was originally made from steel but more recently it has been made from glass.

Suggest one advantage and one disadvantage of using glass for this purpose.

Advantage _____

_____

Disadvantage _____

_____ [2]

Examiner Only	
Marks	Remark

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(Questions continue overleaf)

Examiner Only	
Marks	Remark

7 Some of the earliest biomaterial applications occurred as far back as ancient times when loose teeth were bound together with gold wires.

In more recent times, artificial teeth were tied to neighbouring teeth.

(a) State what biomaterials are and discuss how they are used.

Your answer should include the following:

- definition of a biomaterial;
- the names of the **three** main types of biomaterials and a statement of how each behaves.

Quality of written communication will be assessed in this question.

[6]

(b) A smart material is one in which the property of the material can change when there is a change to its surroundings. A number of examples of the uses of smart materials are:

- contact thermometers
- security markers
- spectacle frames
- touch screens on mobile phones

Complete the following table by choosing from the above list the most suitable example for each smart material.

State a feature which makes the smart material best suited to the chosen example.

Smart Material	Chosen example from above list	Feature
Photochromatic Material		
Shape Memory Alloy		
Thermochromatic Material		

[6]

Examiner Only

Marks	Remark

8 Bronze is an alloy. It consists of 88% copper and 12% tin **by volume**.

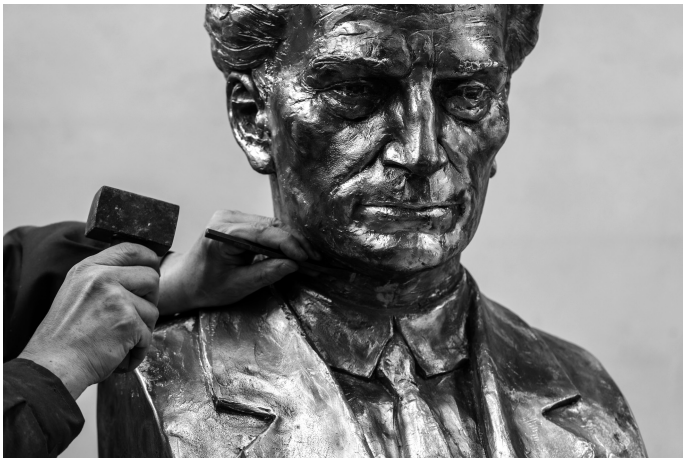

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Fig. 8.1

A sculptor needs to determine the density of bronze used to make a statue.

Density of Copper / gcm^{-3}	Density of Tin / gcm^{-3}	Volume of Bronze Sculpture / cm^3
8.94	7.17	28750

Use the information in the table above to complete the following calculations.

For each part you are advised to show your working.

(a) Determine the volume of copper required to make a statue of bronze.

_____ cm^3 [1]

(b) Calculate the mass of copper required to make this statue.

_____ g [3]

Examiner Only

Marks	Remark

(c) By first finding the volume and mass of tin in this statue, calculate the density of bronze.

Give your answer to three significant figures.

Examiner Only

Marks	Remark

Volume of tin _____ cm^3

Mass of tin _____ g

Density of bronze _____ gcm^{-3} [4]

THIS IS THE END OF THE QUESTION PAPER