Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2024

Centre Number

Candidate Number

Life and Health Sciences

Assessment Unit AS 5
assessing
Material Science

SZ051

[SZ051]
THURSDAY 6 JUNE, MORNING

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.
You must answer the questions in the spaces provided.
Do not write outside the boxed area on each page or on blank pages.
Complete in black ink only. **Do not write with a gel pen.**
Answer **all eight** questions.

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 **8(b)(i)**.

1 **(a)** **(i)** A polymer is an example of a material which has good chemical resistance.

Define **chemical resistance**.

_____

_____ [1]

(ii) Adding another material to steel can increase its chemical resistance.

What material should be added to steel to make stainless steel?

_____ [1]

(iii) What makes alloys more useful than pure metals?

_____

_____ [1]

(iv) Reinforced concrete is made by adding steel rods to concrete.

What type of material is reinforced concrete?

_____

Give a reason for your answer.

_____

_____ [2]

(b) The table below shows various properties related to different materials.

	Material A	**Material B**	**Material C**	**Material D**
Appearance	Transparent	Shiny	Transparent	Opaque
Ductile or Brittle	Both	Ductile	Brittle	Brittle
Ability to conduct heat	Poor	Good	Poor	Poor
Electrical conductivity	Poor	Good	Poor	Poor
Melting point	Varies	High	High	High

Which material, **A**, **B**, **C** or **D**, is best suited to each of the following examples?

Give a reason for your choice.

(i) Brick used for building.

Material _____

Reason _____

_____ [1]

(ii) Copper for electric wires.

Material _____

Reason _____

_____ [1]

[Turn over

2 Biomaterials play a significant role in modern medicine.

They are classified into three distinct categories: bioinert, bioactive and biotolerant.

Some examples of biomaterials are bioglass, silicone and titanium.

(i) Define the term **biomaterial**.

_____

_____ [1]

(ii) Give a brief description of each category.

Bioinert _____

_____

_____

Bioactive _____

_____

_____

Biotolerant _____

_____

_____ [3]

(iii) State the name of the category (bioinert, bioactive or biotolerant) to which each of the following examples belong.

Bioglass _____

Silicone _____

Titanium _____

[3]

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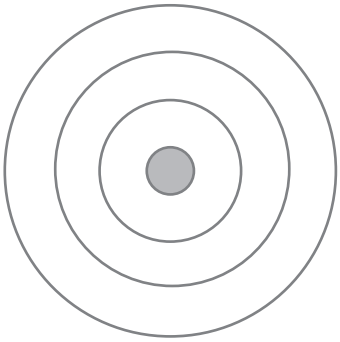
(Questions continue overleaf)

[Turn over

3 **(a)** **(i)** Complete the diagram below to show the arrangement of electrons for silicon $^{28}_{14}Si$.



[2]

(ii) Pure silicon at room temperature is a poor conductor of electricity.

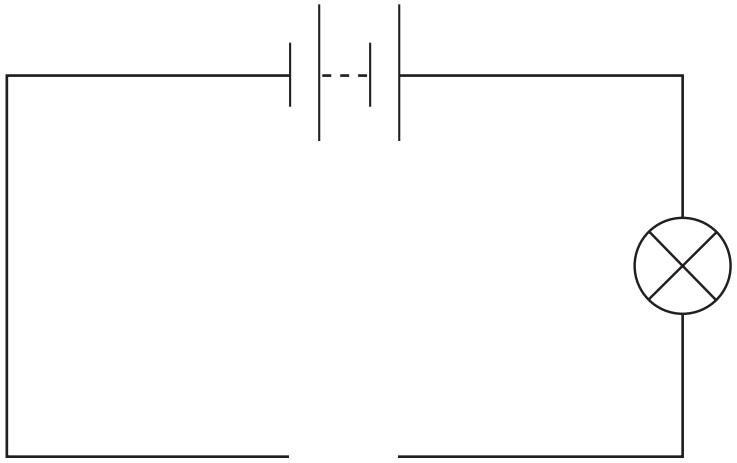
Name the process that would allow pure silicon to conduct electricity better at room temperature.

Identify the elements that could be used in this process.

Process _____

Elements _____ and _____ [3]

(b) (i) Complete the circuit diagram below to include a **forward**-biased diode.



[1]

(ii) What is the depletion layer of a diode?

_____

_____ [1]

(iii) What happens to the depletion layer when the diode is forward-biased?

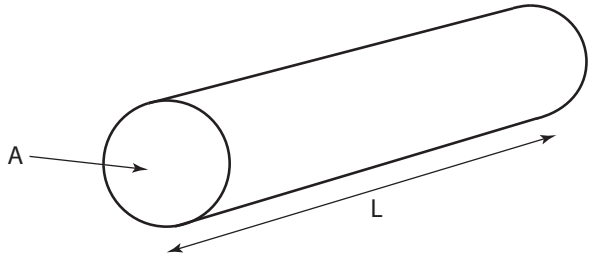
_____ [1]

[Turn over

4 Electrical conductivity, σ, can be calculated using the formula

$$\textbf{Electrical conductivity, } \sigma = \frac{\textbf{L}}{\textbf{RA}}$$

where L is length in metres, R is resistance in ohms and A is cross-sectional area in metres squared.



Source: Principal Examiner

In an experiment to measure the electrical conductivity, a student uses a 2 m length of wire of resistance 0.5 Ω and cross-sectional area $1 \times 10^{-6}\,m^2$.

(i) Using the formula above, calculate the electrical conductivity of the wire.

Include a unit with your answer.

You are advised to show your working.

Conductivity = _____ Unit = _____ [3]

(ii) The wire was replaced with a different wire of the same material and length, but twice the diameter.

How does the electrical conductivity of the new wire compare with the original wire?

_____ [1]

[Turn over

5 **(a)** Complete the table below to describe the Bohr model of an atom in terms of the name, location and relative charge for each particle involved.

Name	Location	Relative charge

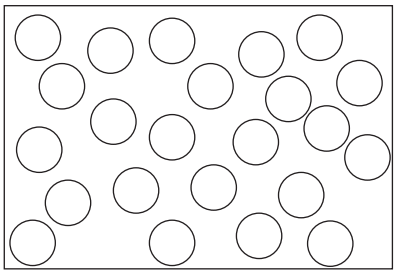
[3]

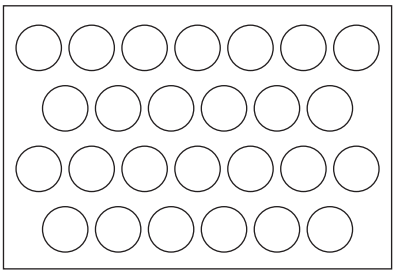
(b) Metals are usually excellent conductors of electricity.

In the box below, draw and label a simple diagram to show the way in which the particles within a metal are arranged.

[3]

(c) The following diagrams show the arrangement of particles in a crystalline solid and an amorphous solid.





Label each diagram above by writing **crystalline** or **amorphous** on the appropriate line. [1]

(d) Complete the table below by placing a tick (✓) under the correct heading for each statement.

Properties	Thermosetting plastics	Thermoplastics
Weak intermolecular forces		
No crosslinks		
Strengthen when heated		
Cannot be remoulded after they are initially formed		
Heat resistant		
uPVC used in window frames		

[3]

[Turn over

6 An experiment was carried out to determine the density of a material.

The table below shows the values of mass and of volume which were measured.

Mass /g	13.5	27.0	54.0	135.0	202.5
Volume /cm^3	5	10	20	50	75

(i) Using the grid on the following page, plot a graph of mass against volume.

Label the vertical axis, include an appropriate unit and select a suitable scale.

Draw the best-fit straight line. [5]

(ii) Use your graph to determine the density of the material.

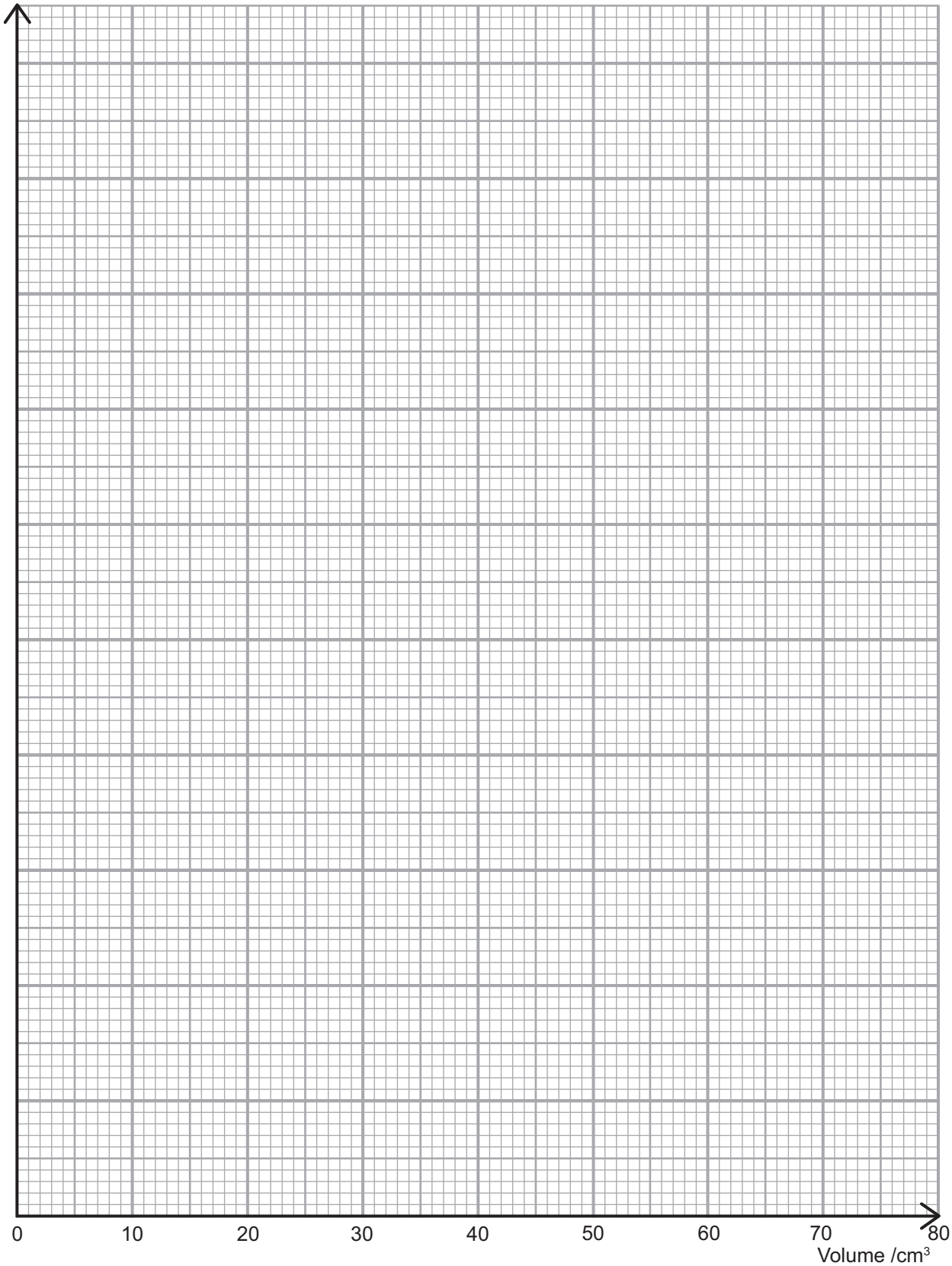
Density = _____ gcm^{-3} [3]

(iii) A second material has a density of 862 kgm^{-3}.

Using your answer from part **(ii)**, how does the density of the second material compare with that of the first material?

_____

_____ [1]



[Turn over

7 **(i)** Graphite, graphene and carbon nanotubes are different forms of the same element.

Draw the structure of graphite and the structure of graphene in the spaces below.

Structure of graphite	Structure of graphene

[3]

(ii) Briefly describe the structure of graphite, graphene and carbon nanotubes.

Graphite _____

_____

_____

Graphene _____

_____

_____

Carbon nanotubes _____

_____

_____ [3]

(iii) State **one** useful physical property of carbon nanotubes.

_____ [1]

(iv) Some nanotubes can be used to carry medication into the body.

The nanotube is inserted by injecting it into the body.

State **one benefit** and **one risk** of using nanotubes for this purpose.

Benefit _____

_____

Risk _____

_____ [2]

(v) Nanomaterials are made up of nanoparticles.

Circle the approximate size of a nanoparticle.

3×10^{-6} m 3×10^{-9} m 3×10^{-12} m

[1]

[Turn over

8 (a) (i) Define **stress**.

_____

_____ [1]

(ii) Define **strain**.

_____

_____ [1]

(b) (i) A student is required to take measurements in order to determine the stress and strain of a metal wire.

State:

- the measurements needed and the equipment required for each measurement to determine the stress and strain; and
- what should be done to ensure the values obtained for stress and strain are both reliable and accurate.

Quality of written communication will be assessed in this question.

Measurements and equipment

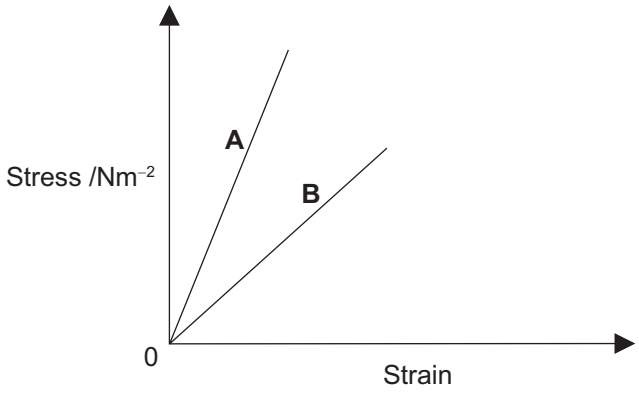
Reliability

Accuracy

[6]

[Turn over

(ii) The sketch below represents a stress–strain graph for two different materials, **A** and **B**.



Which material, **A** or **B**, is stiffer?

Explain your choice.

Material _____

Explanation _____

_____ [2]

(iii) Continue the graph for material **A** to show its behaviour for higher stress. [1]

(iv) On the graph, for material **A**, label the yield strength (**Y**) and the point where the material has ultimate tensile strength (**U**). [2]

(c) A steel wire supports a weight of 85 N and has a stress value of 1.06×10^9 Pa.

The Young modulus for the steel wire is 2.10×10^9 Pa.

You are advised to show your working.

(i) Calculate the strain of the wire.

Strain = _____ [3]

(ii) Calculate the diameter of the wire in mm.

Give your final answer to 2 significant figures.

Diameter = _____ mm [4]

THIS IS THE END OF THE QUESTION PAPER

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

Examiner Number