Q1.

Read this passage about metals.

Metals are crystalline materials. The metal crystals are normally about 20 000 nm (nanometres) in diameter. The atoms inside these crystals are arranged in layers.

A new nanoscience process produces nanocrystalline metals. Nanocrystalline metals are stronger and harder than normal metals.

It is hoped that nanocrystalline metals can be used in hip replacements.

The use of nanocrystalline metals should give people better hip replacements which last longer.

(a) State why metals can be bent and hammered into different shapes.

_____

_____

(1)

(b) How is the size of the crystals in nanocrystalline metals different from the size of the crystals in normal metals?

_____

(1)

(c) Hip joints are constantly moving when people walk.

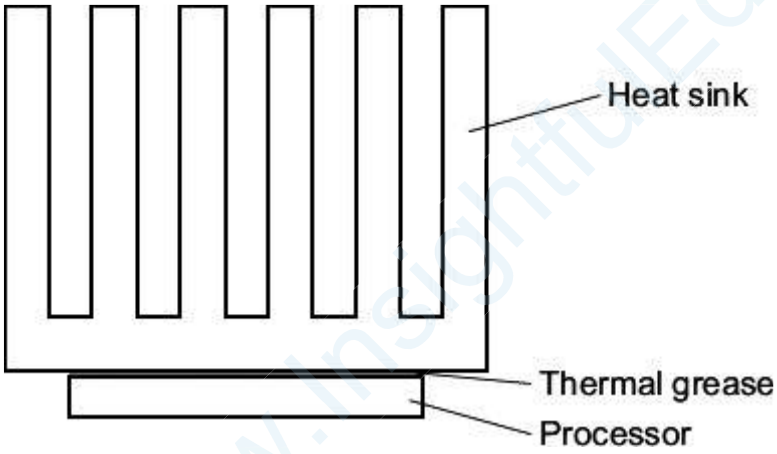
Suggest and explain why the hip replacement made of nanocrystalline metal should last longer than one made of normal metals.

(2)

(Total 4 marks)

Q2.

The diagram shows how a heat sink is placed on top of a processor in a computer.
The heat sink is a large piece of metal which conducts heat away from the processor.
If the processor gets too hot it may be damaged.



(a) (i) Describe the structure of a metal.

(3)

(ii) Why are metals very good conductors of heat?

_____

_____

(1)

(b) When viewed under a microscope, it can be seen that the surfaces of the processor and the heat sink that are in contact are not flat.
There are lots of tiny gaps between the two surfaces.
The gaps contain air, which does not conduct heat very well.
Thermal grease is used to fill the gaps between the processor and the heat sink to improve the transfer of heat from the processor to the heat sink.

One type of thermal grease contains nanosized particles of silver.
The manufacturer claims that the nanosized particles help to transfer heat better than normal sized particles.

(i) How are nanosized particles different from normal sized particles?

_____

_____

(1)

(ii) Suggest **one** reason why nanosized particles of silver might help to transfer heat better than normal sized particles.

_____

_____

(1)

(Total 6 marks)

Q3.

(a) By reference to their structure, explain how the particles in a piece of metal are held together and how the shape of the metal can be changed without it breaking.

(You may use a diagram in your answer.)

_____

_____

_____

_____

_____

_____

_____

(5)

(b) Explain why metals are good conductors of electricity and suggest why this conductivity increases across the periodic table from sodium to magnesium to aluminium.

(4)

(Total 9 marks)

Q4.

The extract below was taken from a leaflet on the uses of platinum. One of the uses described was in making electrodes for spark plugs in car engines. The spark plug produces the spark which ignites the fuel in the engine.

Spark Plugs

The electrodes in a spark plug have to conduct electricity very well. Since they project into the combustion chamber of the engine, they must also be able to withstand extremely high temperatures in a very corrosive atmosphere.

Nickel-based plugs have been produced for many years. They only last a fairly short time. As the electrodes wear, combustion becomes less efficient and the petrol is not burnt completely.

Platinum and other precious metals can now be used in spark plugs. These last much longer and are more efficient. This can help to reduce air pollution.

The table below gives some information about platinum and nickel.

	MELTING POINT (° C)	BOILING POINT (° C)	POSITION IN REACTIVITY SERIES	COST (£/kg)
nickel	1455	2920	Higher than gold	2.5
platinum	1769	4107	below gold	6110

(a) Compare nickel and platinum for use in making the electrodes in spark plugs.

A good answer should give advantages and disadvantages of each metal linking these to the properties of the metals. Marks will be given for the way in which you organise your answer.

You will need a sheet of lined paper.

(8)

(b) (i) Describe the structure and bonding in metals.

(3)

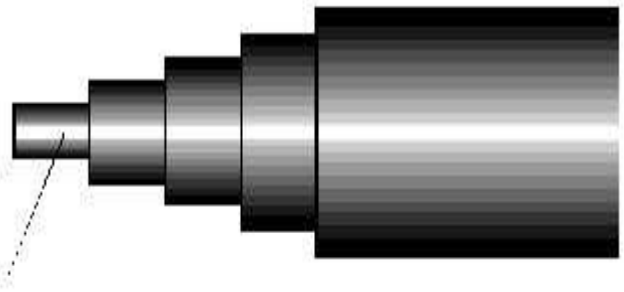
(ii) Explain why metals such as nickel and platinum are good conductors of electricity.

(2)

(Total 13 marks)

Q5.

The drawing shows a high quality wire used to make electrical connections on a hi-fi system.



Multi-strand "OFC" copper
to maitain high signal purity

(a) Copper is used because it is a very good conductor of electricity. Copper is a typical metal.

(i) Describe the structure and bonding in a metal. You may wish to draw a diagram to help you to answer this question.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

_____

_____

_____

_____

_____

_____

(3)

(ii) Explain, by reference to your answer to part (a)(i), why copper conducts electricity.

_____

_____

(1)

(iii) Explain, by reference to your answer to part (a)(i), why copper can be drawn into wires.

_____

_____

(1)

(b) The copper used to make this wire is "OFC" copper. This stands for 'oxygen free copper'.

(i) It is thought that when molten copper is cooled and solidified it can take in some oxygen from the air. This may slightly decrease the conductivity of the copper.

Suggest why the conductivity might be decreased.

_____

_____

_____

_____

(2)

(ii) To make it oxygen free, the copper is heated in an atmosphere of hydrogen.

Explain how this will remove the oxygen.

_____

_____

_____

_____

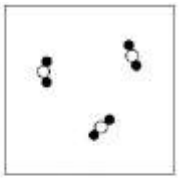
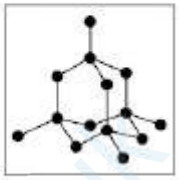
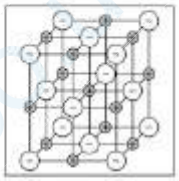
(1)

(Total 8 marks)

Q6.

This question is about different substances and their structures.

(a) Draw **one** line from each statement to the diagram which shows the structure.

Statement	Structure
The substance is a gas	
The substance is a liquid	
The substance is ionic	
The substance is a solid metal	
	

(4)

(c) Why does this element conduct electricity?

Tick **one** box.

It has delocalised electrons ☐

It contains hexagonal rings ☐

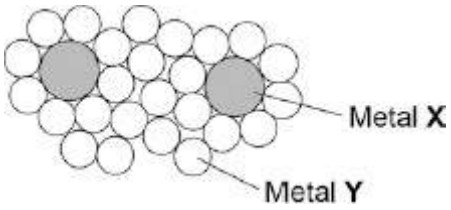
It has weak forces between the layers ☐

It has ionic bonds ☐

(1)

(d) **Figure 2** shows the structure of an alloy.

Figure 2



Explain why this alloy is harder than the pure metal **Y**.

_____

_____

_____

_____

(2)

(e) What percentage of the atoms in the alloys are atoms of **X**?

_____

_____

_____

_____

(2)

(f) What type of substance is an alloy?

Tick **one** box.

Compound ☐

Element ☐

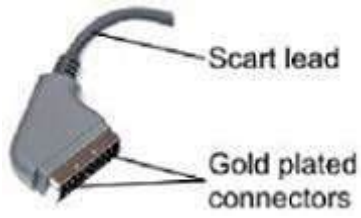
Mixture ☐

(1)

(Total 11 marks)

Q7.

High quality connectors are used to connect a satellite box to a television.
The connectors should conduct electricity very well and should not corrode.



By Alphathon (Own work) [CC-BY-SA-3.0 or GFDL], via Wikimedia Commons

The connectors on this scart lead are coated with gold.

(a) Gold is a typical metal.

(i) Describe the structure and bonding of gold.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(ii) Why is gold a good conductor of electricity?

_____

_____

(1)

(b) The surface of some metals, such as iron, corrode when exposed to the air.

Suggest why this reduces the electrical conductivity of the metal.

_____

_____

_____

_____

(2)

(Total 6 marks)

Q8.

Glass is made from silicon dioxide.

(c) Glass can be coloured using tiny particles of gold. Gold is a metal.

Describe the structure of a metal.

(3)

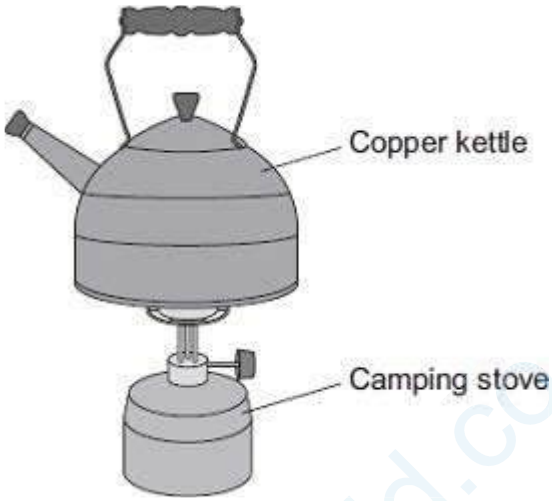
(Total 7 marks)

Q9.

The picture shows a copper kettle being heated on a camping stove.

Copper is a good material for making a kettle because:

- it has a high melting point
- it is a very good conductor of heat.



(a) Explain why copper, like many other metals, has a high melting point.

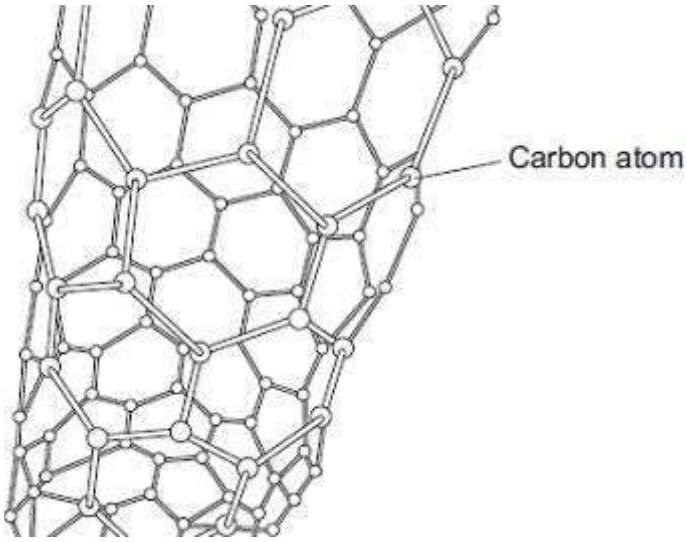
Your answer should describe the structure and bonding of a metal.

(4)

(b) Aeroplanes contain many miles of electrical wiring made from copper. This adds to the mass of the aeroplane.

It has been suggested that the electrical wiring made from copper could be replaced by carbon nanotubes which are less dense than copper.

The diagram shows the structure of a carbon nanotube.



(i) What does the term 'nano' tell you about the carbon nanotubes?

_____

_____

(1)

(ii) (interleave) Like graphite, each carbon atom in the carbon nanotube is joined to three other carbon atoms.

Explain why the carbon nanotube can conduct electricity.

_____

_____

_____

_____

_____

(2)

(Total 7 marks)

Q10.

This question is about aluminium.

(a) Aluminium is a metal.

Draw **one** line from each property of aluminium to the correct reason for that property.

Property	**Reason**
	Aluminium has delocalised electrons

Conducts electricity	Aluminium has layers of atoms which can slide
	Aluminium has strong metallic bonds
High melting point	Aluminium has weak intermolecular forces
	Aluminium has a random arrangement of atoms

(2)

(b) Aluminium can be used to make alloys.

What is meant by an 'alloy'?

_____

_____

(1)

Aluminium is extracted from bauxite.

Bauxite is a mixture which contains aluminium oxide.

(c) Bauxite contains between 15% and 25% aluminium.

Aluminium oxide always contains 53% aluminium.

How does this show that bauxite is a mixture and **not** a compound?

_____

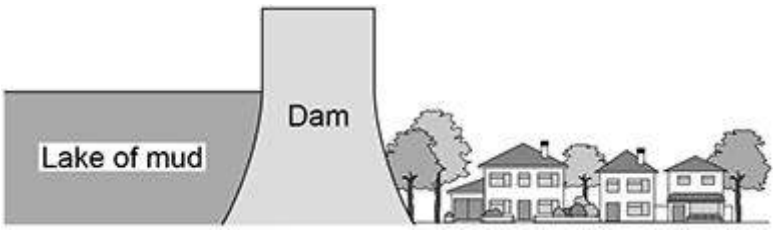
_____

(1)

(d) The waste material from the bauxite is stored in lakes of mud.

The lakes of mud are held in place by dams.

The **image** below shows one of these lakes.



Suggest **two** possible problems with storing the waste material in lakes of mud.

1 _____

2 _____

_____

(2)

Q11.

This question is about small particles.

(a) Coarse particles, fine particles and nanoparticles are all small particles.

Which is the largest particle?

Tick (✓) **one** box.

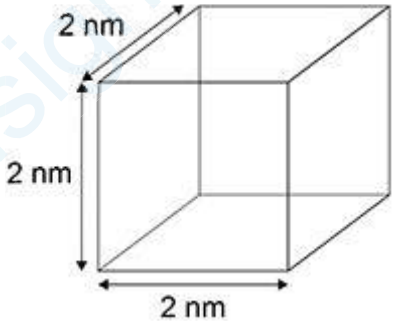
Coarse particle ☐

Fine particle ☐

Nanoparticle ☐

(1)

(b) The figure below shows a cubic nanoparticle.



The surface area of the cubic nanoparticle is 24 nm^2.

Calculate:

- the volume of the cubic nanoparticle
- the simplest surface area : volume ratio of the cubic nanoparticle.

_____

_____

Volume = _____ nm^3

_____

_____

Simplest surface area : volume ratio = _____ : 1

(4)

(c) Catalysts made of nanoparticles are often more effective than catalysts made of normal sized particles.

Complete the sentences.

Compared with normal sized particles, the surface area to volume ratio of nanoparticles is _____.

This means that the mass of a nanoparticle catalyst needed to have the same effect as the same catalyst made of normal sized particles is _____.

(2)

(d) Silver nanoparticles can be added to the material used to make socks.

Some facts about silver and bacteria are:

- silver nanoparticles are small enough to be breathed in
- silver is very expensive
- silver can kill bacteria
- bacteria can cause infections
- bacteria can break down sweat to produce unpleasant smells.

Suggest **one** advantage and **one** disadvantage of wearing socks containing silver nanoparticles.

Advantage _____

_____

Disadvantage _____

_____

(2)

(e) An atom has a radius of 1×10^{-10} m.

A spherical nanoparticle has a radius of 1×10^{-8} m.

How many times larger is the radius of the nanoparticle than the radius of the atom?

Tick (✓) **one** box.

2 times ☐

10 times ☐

100 times ☐

200 times ☐

(1)

(Total 10 marks)

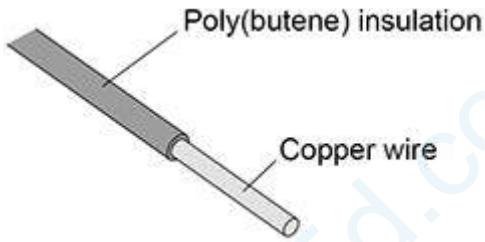
Q12.

This question is about copper wire and copper compounds.

Copper is used to make electrical wires.

Figure 1 shows how copper electrical wire is insulated using an addition polymer called poly(butene).

Figure 1



(c) Describe how scrap copper wire can be recycled to make new copper water pipes.

_____

_____

_____

_____

(2)

(d) Suggest **two** reasons why recycling scrap copper is more sustainable than extracting copper from copper ores.

1 _____

_____

2 _____

_____

(2)

Mark schemes

Q1.

(a) any **one** from:

- they are made of layers
  *do **not** accept line / rows / lattice*
- atoms / ions / particles / layers (of atoms) can slide over each other

1

(b) any **one** from:

- smaller / tiny **or** very small
  *do **not** allow small alone*
- correct size range 1 to 100 nanometres
- a few hundred atoms in size
  if they state smaller and give a size outside range ignore size
  if it is less than 20,000

1

(c) harder

1

plus **one** from:

- so does not wear as quickly / erode as quickly
  ignore corrode
- less vulnerable to damage owtte
  *harder to wear down = **1** mark*
- because they have a high surface area to volume ratio

or

stronger (1)

plus **one** from: (1)

- less likely to break / do not break
  accept withstand pressure
- not as vulnerable to damage owtte
  *harder and stronger alone gains **1** mark*
- do not bend out of shape

- because they have a high surface area to volume ratio

1

[4]

Q2.

(a) (i) *mention of molecules / intermolecular / ionic / covalent* = ***max 2***

atoms / positive ions

1

any **two** from:

- (atoms / positive ions) in regular pattern / lattice / layer / giant structure (or diagram)
- delocalised electrons
  accept electrons move within / through the structure
  allow free (moving) electrons
  allow sea of electrons
- (atoms / positive ions) held together by strong / electrostatic attractions
  allow strong (metallic) bonds

2

(ii) delocalised electrons
accept electrons move within / through the structure
allow free electrons

1

(b) (i) smaller / very small
accept converse
accept 1 - 100 nanometres in size
accept a few hundred atoms
accept larger surface area ***or***
large surface area for their size

1

(ii) nanoparticles / more can fit into (tiny) gaps
allow nanosize particles have large(r) surface area

1

[6]

Q3.

(a) *Idea that*
the electrons do not belong to specific atoms/delocalised electrons
[credit if done on appropriate diagram]
metal atoms form positive ions
the attraction which exists between particles with opposite charges, holds the metal together
no specific bonds exist between adjacent atoms/ions
atoms/ions can slide over each other so allowing metals to bend

each for 1 mark

5

(b) some electrons in the structure are delocalised/free to move

for 1 mark

these free electrons carry the electric current

for 1 mark

from left to right across the period, atoms of elements have more free electrons

gains 1 mark

but from left to right across the period, atoms of elements have more free electrons because they have more electrons in the outer shells

gains 2 marks

4

[9]

Q4.

(a) 8 marks Particularly well structured answer with most points mentioned.

7-6 marks Well structured answer. The two metals will have been compared rather than simply listing advantages/disadvantages. Most of the advantages and disadvantages of each metal have been mentioned.

5-3 marks Some structure to the answer. An attempt to compare the metals by giving some advantages and disadvantages.

2-1 marks Little structure or attempt to compare. Marks gained by listing a few advantages or disadvantages.

Advantages of Nickel:
Relatively low cost which makes the sparking plugs cheaper to produce.
Quite high melting point which is needed because the temperature in the engine is very high.
Good conductor of electricity needed to carry electricity into combustion chamber to produce spark.

Disadvantages of Nickel:
Subject to corrosion in engine which means they only last a short time *because nickel is higher in reactivity than platinum.*
Idea that this leads to reduced efficiency, unburnt petrol and air pollution.

Advantages of Platinum:
Less susceptible to corrosion (not corroded) because platinum is very low in reactivity.
Idea that this improves efficiency and reduces pollution.-
Higher melting point than nickel to withstand the high temperatures in the combustion chamber.
Last a lot longer than nickel electrodes due to low reactivity.
(Sensible extension here could be longer service intervals etc.)-
Good conductor of electricity as for nickel.
Extension here could be linked to the idea that the conductivity does not deteriorate as quickly as nickel.)

Disadvantages of Platinum:
Cost *which will make the sparking plug more expensive.*
A good candidate might justify cost by longer life, better fuel consumption and less pollution.

8

(b) (i) giant structure/lattice/regular arrangements of atoms
any for 1 mark

of atoms/of ions (provided free electrons mentioned)
either for 1 mark

delocalised or free electrons
for 1 mark

3

(ii) electrons free/can move
for 1 mark each

2

[13]

Q5.

(a) (i) **Quality of Written Communication**
The answer to this question requires ideas in good English in a sensible order with correct use of scientific terms. Quality of written communication should be considered in crediting points in the mark scheme.
maximum 2 marks if ideas not expressed well

layers / lattice / giant structure / regular pattern of atoms (diagram)
allow layers / lattice / giant structure / regular pattern of ions
*do **not** accept particles*

1

outer (shell) electrons
accept valence electrons

1

(free to) move (through whole structure)
accept delocalised / mobile / free

1

(ii) the free electrons (allow the metal to conduct electricity)
accept electrons move / mobile / delocalised

1

(iii) atoms / ions / layers can slide / slip / move over each other

1

(b) (i) copper oxide formed **or** Cu reacts with oxygen **or** Cu is oxidised

1

this is a poor conductor **or** gets in the way of free moving electrons **or** fewer mobile electrons
*do **not** accept electricity*

1

or

oxygen atoms / oxygen molecules / oxide ions in metal

do not accept oxygen pockets / bubbles

prevents / disrupts flow of electrons /
current or fewer mobile electrons (1)

*do **not** accept macro explanations*
*do **not** accept electricity*

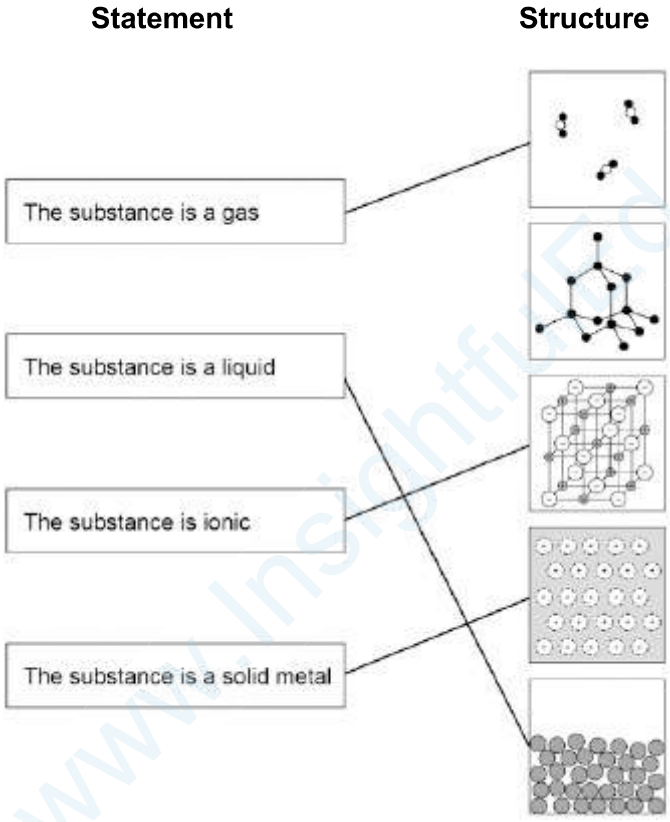
(ii) hydrogen reacts with oxygen or water is formed **or** hydrogen reduces copper oxide etc.

1

[8]

Q6.

(a)



more than one line drawn from a variable negates the mark

4

(c) It has delocalised electrons

1

(d) the atoms / particles / ions are different sizes

*do **not** accept molecules*

1

so there are no rows / layers to slide

accept the layers are disrupted

1

(e) $\frac{2}{27} \times 100$

1

7.4%

1

*allow 7.4% with no working shown for **2** marks*

(f) Mixture

1

[11]

Q7.

(a) (i) *mention of molecules **or** any reference to incorrect bonding = max 2*

giant structure / lattice or particles arranged in a regular pattern

allow close packed / layers

1

sea of electrons / delocalised electrons

allow free electrons

1

positive ions and electrons attract each other

ignore metallic bonds

appropriately labelled diagrams can gain first two marks

1

(ii) (sea of) electrons can move <u>through the structure</u>

allow free / roaming / mobile electrons

or delocalised electrons

1

(b) (metal) oxide / ionic compound formed

1

ions not free to move

or

electrons cannot move <u>through the structure</u>

allow no / fewer delocalised / free / roaming / mobile electrons

1

[6]

Q8.

(c) *lattice / regular pattern / layers / giant structure / close-packed arrangement*

1

(of) positive ions **or** (of) atoms

1

(with) delocalised / free electrons

*reference to incorrect particles **or** incorrect bonding **or** incorrect structure = max **2***

1

[7]

Q9.

(a) *reference to incorrect bonding **or** incorrect structure **or** incorrect particles = max **3***

giant structure / lattice

ignore many bonds

1

made up of <u>positive</u> ions surrounded by delocalized / free electrons

allow <u>positive</u> ions surrounded by a sea of electons

1

with strong bonds / attractions

allow hard to break for strong

1

so a lot of energy is needed to break these bonds / attractions / forces

ignore high temperature

ignore heat

1

(b) (i) that they are <u>very</u> small

or

1-100 nanometres **or** a few(hundred) atoms

accept tiny / really small / a <u>lot</u> smaller / any indication of very small eg. microscopic, smaller than the eye can see

ignore incorrect numerical values if very small is given

1

(ii) delocalised / free electrons

allow sea of electrons

1

one <u>non-bonded</u> electron from each atom

accept electron(s) <u>moving through the structure / nanotube</u>

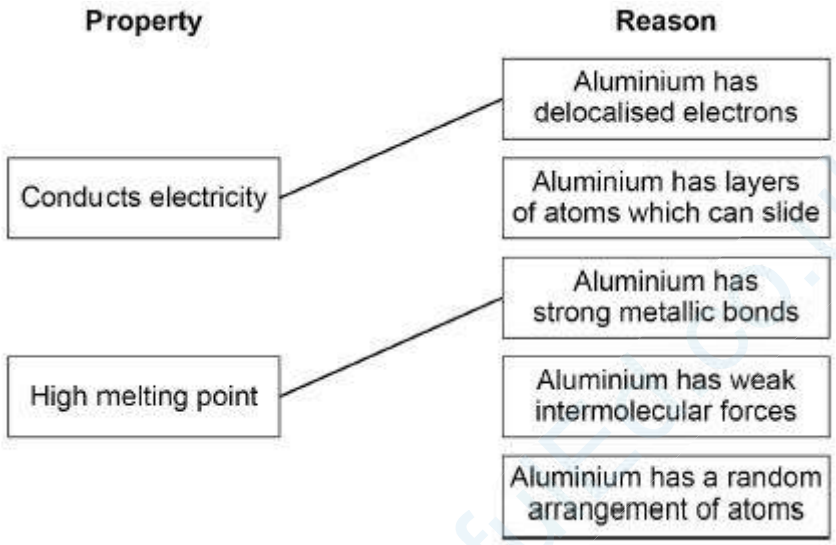
allow electron(s) carry / form / pass current / charge

1

[7]

Q10.

(a)



1

additional line from a box on the left negates the mark from that box

1

(b) a mixture of metals

allow a mixture of a metal with other elements

1

(c) bauxite contains a variable percentage of aluminium

allow converse argument

allow bauxite does not have a fixed proportion / percentage of aluminium

1

(d) any **two** from:

- danger of dam bursting

  allow the lake (of mud) could overflow
- leakage of toxic substances from mud to environment
- water pollution
- damage to habitats
- visual pollution
- (dam) blocks light
- reduces the value of houses

  allow unpleasant smell

2

Q11.

(a) coarse particle

1

(b) (volume =) 2^3

allow (volume =) 2×2×2

1

= 8 (nm^3)

1

(surface area : volume) = 24 : 8

allow correct use of an incorrectly calculated volume

1

(simplest ratio) = 3 : 1

1

(c) high(er) / large(r)

1

lower / less / smaller

1

(d) (advantage)
any **one** from:
- stops (unpleasant) smells
- can stop (foot) infections

allow specific (foot) infections

allow silver can kill bacteria

1

(disadvantage)
any **one** from:
- high cost of socks

allow silver is (very) expensive

- could be harmful if breathed in

1

(e) 100 times

1

[10]

Q12.

(c) (wire heated until) copper melts

1

(re)cast / reformed (into pipes)

allow (re)shaped / extruded / (re)moulded

1

(d) any **two** from: (recycling scrap copper)
- uses less energy

- conserves copper (ore)
- (produces) less waste

  allow less landfill required

- specified environmental impact

  allow converse statements for extracting copper from ores

  ignore references to cost