AQA GCSE CHEMISTRY (HIGHER) · 8462

CHEMISTRY



EXAM QUESTION PACK

4.2.4 BULK AND SURFACE PROPERTIES OF MATTER INCLUDING NANOPARTICLES

SCORE	PERCENTAGE
/143	%

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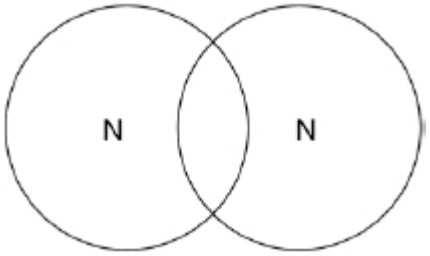
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Q1.

This question is about structure and bonding.

(a) Complete the dot and cross diagram to show the covalent bonding in a nitrogen molecule, N_2

Show only the electrons in the outer shell.



(2)

(b) Explain why nitrogen is a gas at room temperature.

Answer in terms of nitrogen's structure.

_____

_____

_____

_____

_____

_____

(3)

(c) Graphite and fullerenes are forms of carbon.

Graphite is soft and is a good conductor of electricity.

Explain why graphite has these properties.

Answer in terms of structure and bonding.

_____

_____

_____

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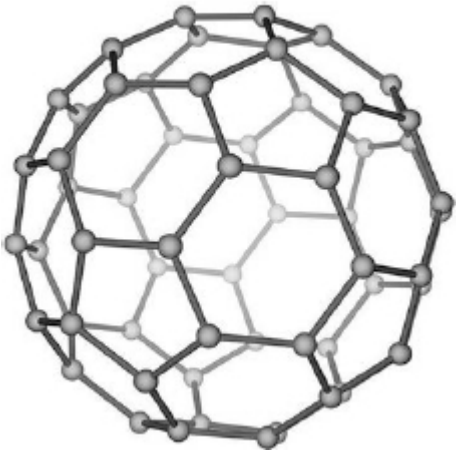
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_____

(4)

(d) **Figure 1** shows a model of a Buckminsterfullerene molecule.

Figure 1



A lubricant is a substance that allows materials to move over each other easily.

Suggest why Buckminsterfullerene is a good lubricant.

Use **Figure 1**.

_____

_____

_____

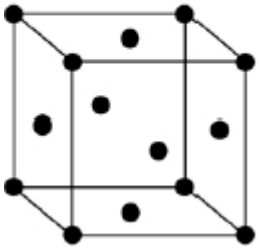
_____

(2)

Silver can form cubic nanocrystals.

Figure 2 represents a silver nanocrystal.

Figure 2



(e) A silver nanocrystal is a cube of side 20 nm

Calculate the surface area to volume ratio of the nanocrystal.

_____

_____

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_____

_____

_____

Surface area to volume ratio = _____

(3)

(f) Silver nanoparticles are sometimes used in socks to prevent foot odour.

Suggest why it is cheaper to use nanoparticles of silver rather than coarse particles of silver.

_____

_____

_____

_____

(2)

(Total 16 marks)

Q2.

The figure below shows magnesium burning in air.



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(a) Look at the figure above.

How can you tell that a chemical reaction is taking place?

_____

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_____

(1)

(b) Name the product from the reaction of magnesium in the figure.

_____

(1)

(c) The magnesium needed heating before it would react.

What conclusion can you draw from this?

Tick **one** box.

The reaction is reversible ☐

The reaction has a high activation energy ☐

The reaction is exothermic ☐

Magnesium has a high melting point ☐

(1)

(d) A sample of the product from the reaction in the figure above was added to water and shaken.

Universal indicator was added.

The universal indicator turned blue.

What is the pH value of the solution?

Tick **one** box.

1 ☐

4 ☐

7 ☐

9 ☐

(1)

(e) Why are nanoparticles effective in very small quantities?

Tick **one** box.

They are elements ☐

They are highly reactive ☐

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They have a low melting point ☐

They have a high surface area to volume ratio ☐

(1)

(f) Give **one** advantage of using nanoparticles in sun creams.

_____

_____

(1)

(g) Give **one** disadvantage of using nanoparticles in sun creams.

_____

_____

(1)

(h) A coarse particle has a diameter of 1×10^{-6} m.
A nanoparticle has a diameter of 1.6×10^{-9} m.

Calculate how many times bigger the diameter of the coarse particle is than the diameter of the nanoparticle.

_____

_____

_____

_____

(2)

(Total 9 marks)

Q3.

This question is about atoms, molecules and nanoparticles.

(a) Different atoms have different numbers of sub-atomic particles.

(i) An oxygen atom can be represented as $^{16}_{8}O$

Explain why the mass number of this atom is 16.

You should refer to the numbers of sub-atomic particles in the nucleus of the atom.

_____

_____

_____

_____

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_____

_____

(2)

(ii) Explain why $^{12}_{6}C$ and $^{14}_{6}C$ are isotopes of carbon.

You should refer to the numbers of sub-atomic particles in the nucleus of each isotope.

_____

_____

_____

_____

_____

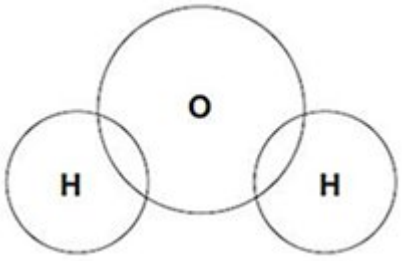
_____

(3)

(b) Hydrogen atoms and oxygen atoms chemically combine to produce water molecules.

(i) Complete the figure below to show the arrangement of the outer shell electrons of the hydrogen and oxygen atoms in a molecule of water.

Use dots (•) or crosses (×) to represent the electrons.



(2)

(ii) Name the type of bonding in a molecule of water.

_____

(1)

(iii) Why does pure water **not** conduct electricity?

_____

_____

(1)

(c) Nanoparticles of cobalt oxide can be used as catalysts in the production of hydrogen from water.

(i) How does the size of a nanoparticle compare with the size of an atom?

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_____

_____

(1)

(ii) Suggest **one** reason why 1 g of cobalt oxide nanoparticles is a better catalyst than 1g of cobalt oxide powder.

_____

_____

(1)

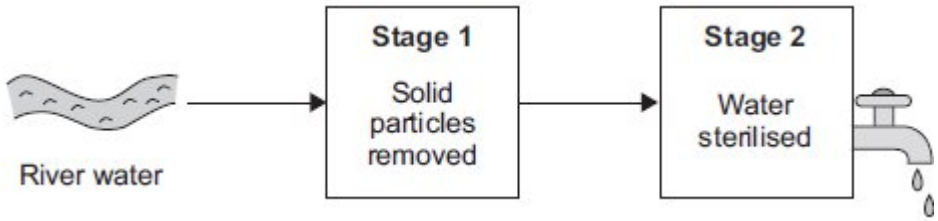
(Total 11 marks)

Q4.

This question is about water.

River water needs to be treated before it is safe to drink.

(a) The diagram shows two stages of the treatment of river water.



(i) What is the name of the process used to remove solid particles in **Stage 1**?

Tick (✓) **one** box.

Crystallisation ☐

Fermentation ☐

Filtration ☐

(1)

(ii) What is added in **Stage 2** to sterilise the water?

Tick (✓) **one** box.

Chlorine ☐

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Fluoride ☐

Potassium ☐

(1)

(b) Toxic substances in river water are removed by adding very small amounts of iron oxide nanoparticles.

(i) How is the size of nanoparticles different from normal-sized particles?

_____

_____

(1)

(ii) Nanoparticles are needed in only very small amounts.

Suggest why.

_____

_____

(1)

(c) In certain areas of the UK, tap water contains aluminium ions.

What would you **see** when sodium hydroxide solution is added drop by drop to tap water containing aluminium ions?

_____

_____

_____

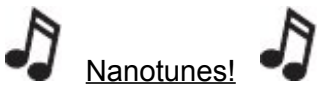
_____

(2)

(Total 6 marks)

Q5.

The article gives some information about graphene.



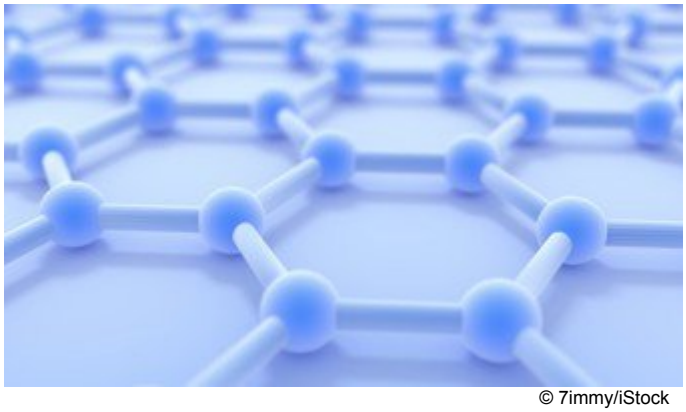
Carbon can be made into nano-thin, strong sheets called graphene.

A graphene sheet is a single layer of graphite.

Graphene conducts electricity and is used in loudspeakers.

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The picture shows the structure of graphene.



© 7immy/iStock

(a) Use the picture and your knowledge of bonding in graphite to:

(i) explain why graphene is strong;

_____

_____

_____

_____

_____

_____

(3)

(ii) explain why graphene can conduct electricity.

_____

_____

_____

_____

_____

_____

(2)

(b) Graphite is made up of layers of graphene.

Explain why graphite is a lubricant.

_____

_____

_____

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(2)

(Total 7 marks)

Q6.

This question is about diamonds.

Draw a ring around the correct answer to complete each sentence.

(a) Diamonds are found in meteorites.

(i) Meteorites get very hot when they pass through the Earth's atmosphere, but the diamonds do not melt.

Diamond has a | high / low / very low | melting point.

(1)

(ii) Most diamonds found in meteorites are nanodiamonds.

A nanodiamond contains a few | hundred / thousand / million. | atoms

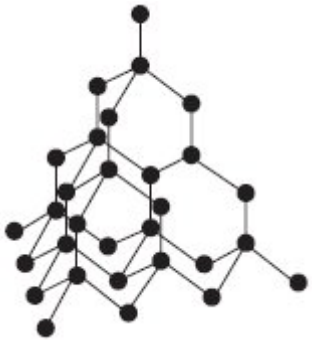
(1)

(b) Diamonds are used for the cutting end of drill bits.

Diamonds can be used for drill bits because they are | hard. / shiny. / soft.

(1)

(c) The figure below shows the arrangement of atoms in diamond.



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(i) Diamond is made from [carbon / nitrogen / oxygen] atoms.

(1)

(ii) Each atom in diamond is bonded to [three / four / five] other atoms.

(1)

(iii) Diamond has a giant [covalent / ionic / metallic] structure.

(1)

(iv) In diamond [all / none / some] of the atoms are bonded together.

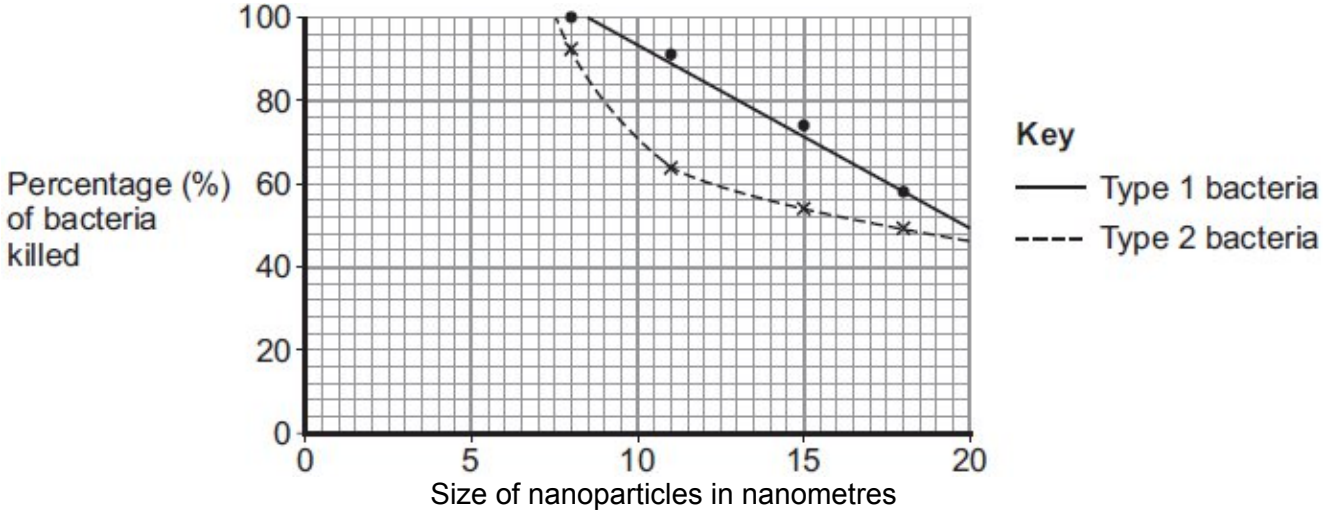
(1)

(Total 7 marks)

Q7.

Magnesium oxide nanoparticles can kill bacteria.

The figure below shows the percentage of bacteria killed by different sized nanoparticles.



(a) (i) Give **two** conclusions that can be made from the figure above.

_____

_____

_____

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_____

_____

_____

(2)

(ii) Points are plotted for only some sizes of nanoparticles.

Would collecting and plotting data for more sizes of nanoparticles improve the conclusions?

Give a reason for your answer.

_____

_____

(1)

(b) Magnesium oxide contains magnesium ions (Mg^{2+}) and oxide ions (O^{2-}).

Describe, as fully as you can, what happens when magnesium atoms react with oxygen atoms to produce magnesium oxide.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 7 marks)

Q8.

Read the article and then answer the questions.

Nanotennis!

Tennis balls contain air under pressure, which gives them their bounce. Normal tennis balls are changed at regular intervals during tennis matches because they slowly lose some of the air. This means that a large number of balls are needed for a tennis tournament.

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© Feng Yu/iStock

'Nanocoated' tennis balls have a 'nanosize' layer of butyl rubber. This layer slows down the escape of air so that the ball does not lose its pressure as quickly. The 'nanocoated' tennis balls last much longer and do not need to be replaced as often.

(a) Tick (✓) the best description of a 'nanosize' layer.

Description	Tick (✓)
A layer one atom thick.	
A layer a few hundred atoms thick.	
A layer millions of atoms thick.	

(1)

(b) Suggest **two** ways in which using 'nanocoated' tennis balls would be good for the environment.

_____

_____

_____

_____

_____

(2)

(Total 3 marks)

Q9.

Nanoparticles have many uses.

(a) (i) Tick (✔) **one** use of nanoparticles.

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In the extraction of iron ☐

In suntan creams ☐

In the test for oxygen ☐

(1)

(ii) How is the size of nanoparticles different from normal-sized particles?

Draw a ring around the correct answer.

much smaller **same size** **much larger**

(1)

(b) Very small amounts of cerium oxide nanoparticles can be added to diesel fuel.

The cerium oxide is a catalyst.

(i) Draw a ring around the correct answer to complete the sentence.

Only a very small amount of cerium oxide nanoparticles is needed because

the nanoparticles

are elements.
are very reactive.
have a high surface area to volume ratio.

(1)

(ii) Explain how a catalyst increases the rate of a reaction.

_____

_____

_____

_____

_____

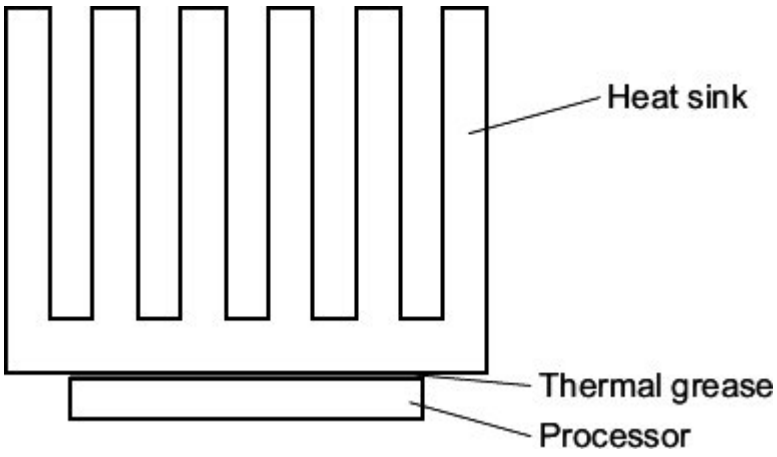
(2)

(Total 5 marks)

Q10.

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.

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(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)

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

_____

_____

(1)

(Total 6 marks)

Q11.

Gold and gold ions are used as catalysts.

(a) An atom of gold is represented as:

$$^{197}_{79}\mathrm{Au}$$

Complete the sentences.

The atomic number of gold is _____

The number of electrons in an atom of gold is _____

(2)

(b) Scientists have found that gold nanoparticles are very good catalysts.

Draw a ring around the correct answer to complete the sentence.

A gold nanoparticle contains a few | hundred / thousand / million | atoms.

(1)

(c) The formation of a gold ion (Au^{3+}) from a gold atom (Au) is shown in the symbol equation.

$$Au \rightarrow Au^{3+} + 3e^-$$

(i) Complete the sentence.

The particles lost when a gold atom becomes a gold ion

are called _____

(1)

(ii) Draw a ring around the correct answer to complete the sentence.

one.

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The number of these particles lost when a gold atom becomes a gold ion is

two.
three.

(1)

(d) Gold ions are used as a catalyst in the reaction to make chloroethene.

How does a catalyst help a reaction?

_____

(1)

(e) Chloroethene can react to make a thermosoftening polymer.

(i) Draw a ring around the correct answer to complete the sentence.

When heated, a thermosoftening polymer will

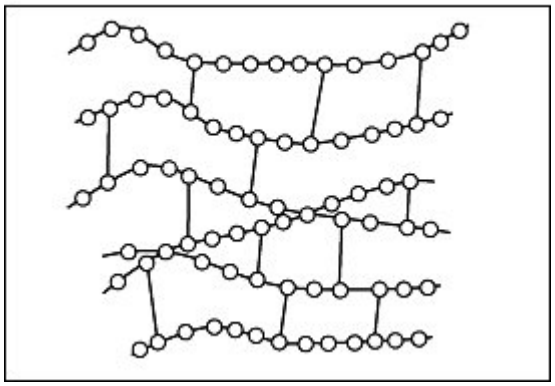
dissolve.
melt.
solidify.

(1)

(ii) Polymer **B** is a different type of polymer.

The diagram shows the structure of polymer **B**.

Polymer B



How can you tell from the diagram that polymer **B** is **not** thermosoftening?

_____

_____

(1)

(Total 8 marks)

Q12.

This question is about calcium hydroxide.

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Ancient artworks and monuments can be protected from acid rain if the surface is sprayed with calcium hydroxide nanoparticles.



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

(a) Calcium hydroxide has the formula $Ca(OH)_2$

Why are there two hydroxide ions for each calcium ion in the formula?

_____

_____

_____

(1)

(b) The calcium hydroxide is used in the form of *nanoparticles*.

What are *nanoparticles*?

_____

_____

(1)

(c) A student added water to calcium oxide to make calcium hydroxide.

The equation for the reaction is shown below.

$$CaO + H_2O \rightarrow Ca(OH)_2$$

Calculate the maximum mass of calcium hydroxide which could be made from 2.00 g of calcium oxide.

Relative atomic masses (A_r): H = 1; O = 16; Ca = 40.

_____

_____

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_____

_____

_____

_____

Maximum mass of calcium hydroxide = _____ g

(3)

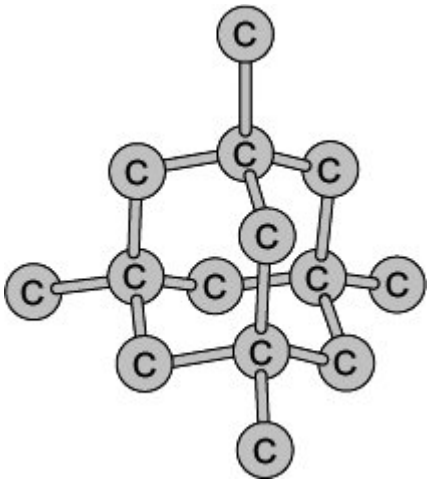
(Total 5 marks)

Q13.

Liquids containing nanoparticles of diamond are used as abrasives.
Nanoparticles of diamond can be used to grind down surfaces to give them a very smooth polished finish.



Abrasive liquid containing nanoparticles of diamond



Model of part of the diamond structure

(a) Diamond is made of one element.
Draw a ring around the name of this element.

calcium **carbon** **chromium** **cobalt**

(1)

(b) Tick (✓) **two** statements in the table which explain why diamond is hard.

Statement	Tick (✓)
It is made of layers.	
It has weak covalent bonds.	

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Each atom is joined to four other atoms.	
It has a giant structure.	
It has strong ionic bonds.	

(2)

(c) Draw a ring around the correct answer to complete the sentence.

Nanoparticles of diamond are

very small.

large.

very large.

(1)

(Total 4 marks)

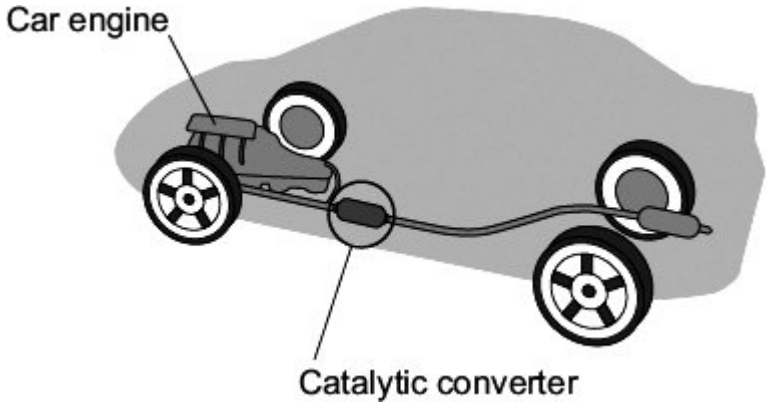
Q14.

Read the information about car engines.

Burning petrol in air is an exothermic reaction. This reaction is used in car engines.

When petrol burns it produces harmful substances such as nitrogen oxides and carbon monoxide.

A catalytic converter stops these harmful substances being released into the air.



(a) Draw a ring around the correct answer to complete each sentence.

(i) The exothermic reaction makes the temperature

of the engine

decrease.

increase.

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stay the same.

(1)

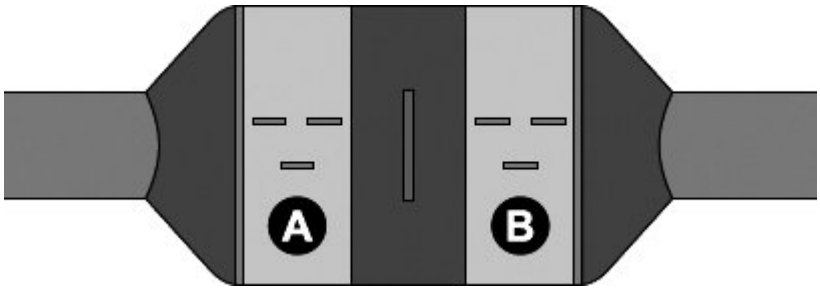
(ii) This is because during

exothermic reactions

energy is taken in from the surroundings.
energy is given out to the surroundings.
there is no energy change.

(1)

(b) The diagram shows a catalytic converter which removes harmful substances.
The catalytic converter has two parts, **A** and **B**, which contain different catalysts.



(i) The equation for the reaction that takes place in part **A** is:

$$2NO \rightarrow N_2 + O_2$$

Which **one** of the substances shown in the equation is a compound?

Give the formula of this compound.

_____

(1)

(ii) The equation for the reaction that takes place in part **B** is:

$$2CO + O_2 \rightarrow 2CO_2$$

Why is it important to stop carbon monoxide (CO) from being released into the air?

_____

_____

(1)

(c) The table lists some statements about catalysts. Only **two** statements are correct.

Tick (✓) the **two** correct statements.

Statement	**Tick (✓)**

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A catalyst can speed up a chemical reaction.	
A catalyst is used up in a chemical reaction.	
Different reactions need different catalysts.	
A catalyst does **not** change the rate of a chemical reaction.	

(2)

(d) Modern catalytic converters contain nanosized particles of catalyst.
Less catalyst is needed when nanosized catalyst particles are used.

(i) Complete the sentence.

The size of nanosized particles is _____ than normal sized particles.

(1)

(ii) The catalysts contain platinum.

Suggest why a manufacturer of catalytic converters would want to use less catalyst.

_____

_____

(1)

(Total 8 marks)

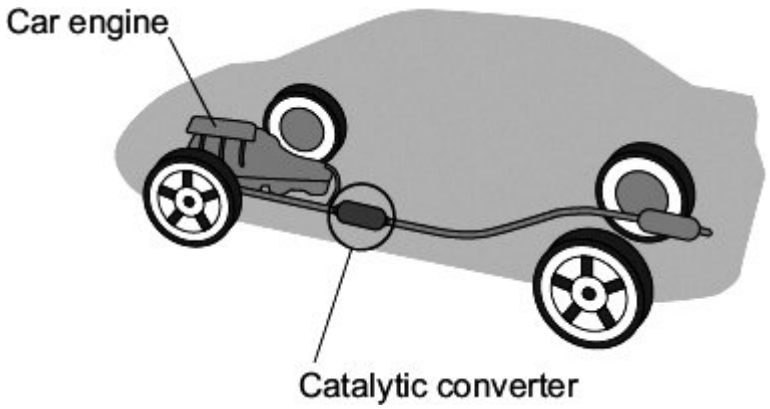
Q15.

Read the information about car engines.

Burning petrol in air is an *exothermic* reaction. This reaction is used in car engines.

When petrol burns it produces harmful substances such as nitrogen oxides and carbon monoxide.

A catalytic converter stops these harmful substances being released into the air.



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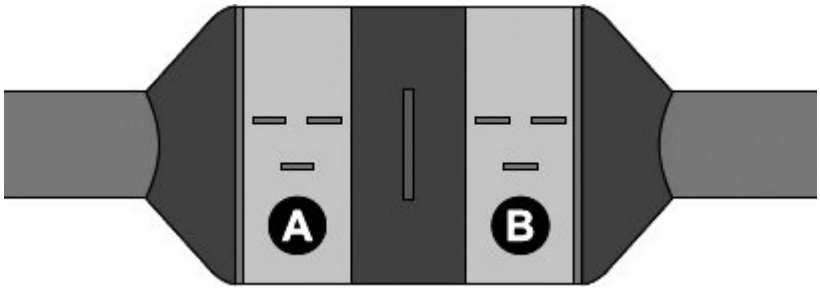
(a) The reaction is *exothermic*. What is the meaning of *exothermic*?

_____

_____

(1)

(b) The catalytic converter has two parts shown as **A** and **B** in the diagram.



Part **A** contains a catalyst made from platinum and rhodium.

Part **B** contains a catalyst made from platinum and palladium.

(i) Why are catalysts used in chemical reactions?

_____

_____

(1)

(ii) One reaction in part **A** is shown by this equation.

$$2NO \rightarrow N_2 + O_2$$

Suggest why this reaction helps the environment.

_____

_____

(1)

(iii) The equation for one of the reactions in part **B** is shown below.

Balance this equation.

$$____\ CO + O_2 \rightarrow ____\ CO_2$$

(1)

(iv) The catalytic converter works for many years without replacing the catalyst.

Explain why the catalyst does not need to be replaced.

_____

_____

(1)

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(v) Suggest why different catalysts are used in parts **A** and **B**.

_____

_____

(1)

(c) Modern catalytic converters contain nanosized particles of catalyst. Using nanosized particles reduces the cost of the catalytic converter.

Suggest and explain why the use of nanosized catalyst particles reduces the cost of the catalytic converter.

Your answer should include information about the size and surface area of the particles.

_____

_____

_____

_____

_____

_____

_____

(3)

(Total 9 marks)

Q16.

Read the article and then answer the questions.

TOXIC SOCKS?

Silver nanoparticles are added to the fibres used to make some socks. Silver has the special property that it can kill bacteria. As a result there are no unpleasant smells when wearing these socks.

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Some scientists are concerned about the use of silver nanoparticles in socks.

The silver can be released from the socks when they are washed. This silver may end up in rivers. Silver in rivers may kill fish.

Scientists found that some makes of socks release the silver more easily than others. Socks in which the silver nanoparticles are trapped in the fibres released very little silver when washed.

By tfkrawksmysocks [CC BY-SA 2.0], via Flickr

(a) Suggest why silver stops unpleasant smells when wearing the socks.

_____

_____

(1)

(b) How is the size of silver nanoparticles different from normal sized silver particles?

_____

(1)

(c) The silver nanoparticles are more effective at preventing unpleasant smells than normal sized silver particles.

Suggest why.

_____

_____

(1)

(d) The silver nanoparticles should be trapped in the sock fibres.

Use the information in the article to explain why.

_____

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_____

_____

_____

(2)

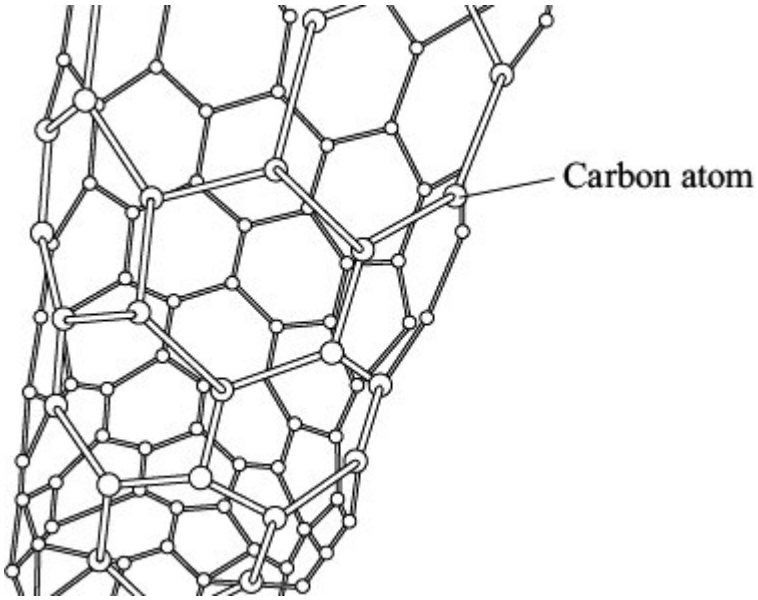
(Total 5 marks)

Q17.

Lightweight handlebars for bicycles are made from materials containing carbon nanotubes.

Carbon nanotubes are lightweight but very strong.

The diagram shows the structure of a carbon nanotube.



(a) What does the term 'nano' tell you about the diameter of carbon nanotubes?

Tick (✓) the correct answer in the table.

Answer	Tick (✓)
The diameter of the tube is very small.	
The diameter of the tube is large.	
The diameter of the tube is very large	

(1)

(b) Look at the diagram and then draw a ring around the correct word to complete each sentence.

(i) Carbon nanotubes are similar to graphite because each carbon atom is joined

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to [two / three / four] other carbon atoms.

(1)

(ii) The carbon atoms are joined by [covalent / ionic / metallic] bonds.

(1)

(iii) Carbon nanotubes are very strong because the [atoms / bonds / electrons] are hard to break.

(1)

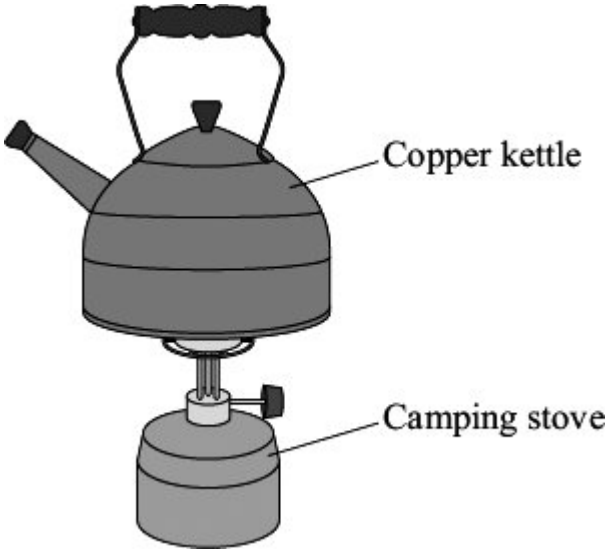
(Total 4 marks)

Q18.

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.
You should describe the structure and bonding of a metal in your answer.

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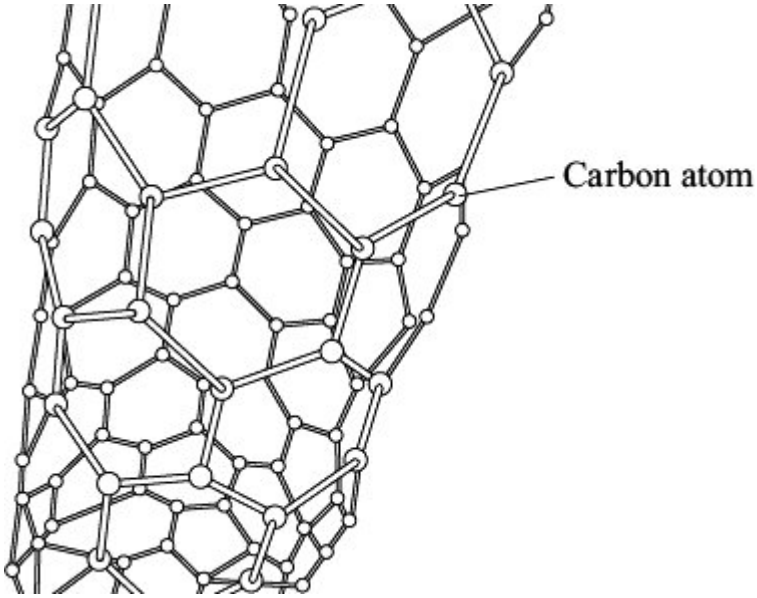
_____

(4)

(b) An aeroplane contains 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 lighter carbon nanotubes.

The diagram shows the structure of a carbon nanotube.



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

_____

_____

(1)

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

Explain why the carbon nanotube can conduct electricity.

_____

_____

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_____

_____

(2)

(Total 7 marks)

Q19.

Read the article and then answer the questions that follow.

Nanotennis!

Tennis balls contain air under pressure, which gives them their bounce. Normal tennis balls are changed at regular intervals during tennis matches because they slowly lose some of the air. This means that a large number of balls are needed for a tennis tournament, using up a lot of materials.



'Nanocoated' tennis balls have a 'nanosize' layer of butyl rubber. This layer slows down the escape of air so that the ball does not lose its pressure as quickly. The 'nanocoated' tennis balls last much longer and do not need to be replaced as often.

(a) How does the 'nanosize' layer make the tennis balls last longer?

_____

_____

(1)

(b) Put a tick (✓) next to the best description of a 'nanosize' layer.

Description	(✓)
A layer one atom thick.	
A layer a few hundred atoms thick.	

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A layer millions of atoms thick.	

(1)

(c) Suggest why using 'nanocoated' tennis balls would be good for the environment.

_____

_____

_____

_____

_____

(2)

(Total 4 marks)

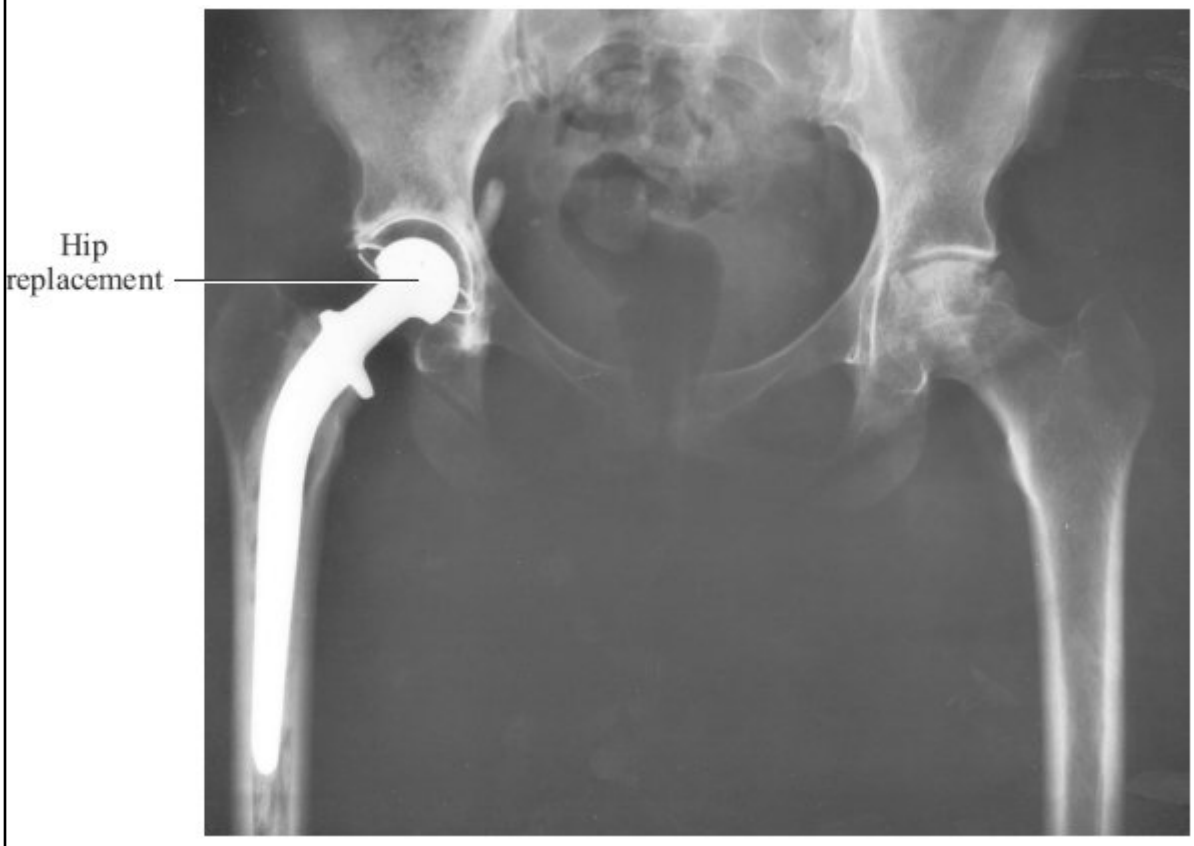
Q20.

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

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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)

Q21.

Read the article and then answer the questions.

Nanotennis!

Tennis balls contain air under pressure, which gives them their bounce. Normal tennis balls are changed at regular intervals during tennis matches because they slowly lose some of the air.

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'Nanocoated' tennis balls have a 'nanosize' layer of butyl rubber. This layer slows down the escape of air so that the ball does not lose its pressure as quickly.

(a) What is the meaning of *nanosize*?

_____

_____

(1)

(b) Suggest why using 'nanocoated' tennis balls would be good for the environment.

_____

_____

_____

_____

(2)

(Total 3 marks)

Q22.

Read the article about the use of nanoparticles in sun creams.

Sun creams

Many sun creams use nanoparticles. These sun creams are very good at absorbing radiation, especially ultraviolet radiation. Owing to the particle size, the sun creams spread more easily, cover better and save money because you use less. The new sun creams are also transparent, unlike traditional sun creams which are white. The use of nanoparticles is so successful that they are now used in more than 300 sun cream products.

Some sun creams contain nanoparticles of titanium oxide. Normal-sized

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particles of titanium oxide are safe to put on the skin.

It is thought that nanoparticles can pass through the skin and travel around the body more easily than normal-sized particles. It is also thought that nanoparticles might be toxic to some types of cell, such as skin, bone, brain and liver cells.

(a) Explain why nanoparticles pass through the skin and travel around the body more easily than normal-sized particles of titanium oxide.

_____

_____

_____

_____

(2)

(b) Explain why sun creams containing nanoparticles should be tested further.

_____

_____

(1)

(c) Suggest why some companies that make sun creams might not want to do more tests.

_____

_____

_____

_____

(2)

(Total 5 marks)

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