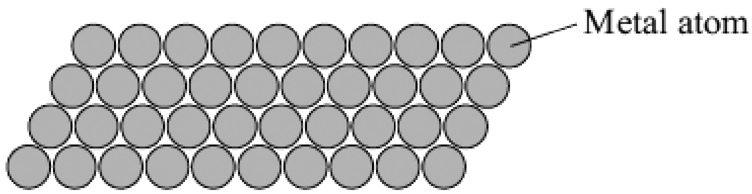
1 Metal is bent and shaped to make a car body.

The diagram below represents how atoms are arranged in a metal.



Which **two** statements in the table best explain why the metal can be bent and shaped?

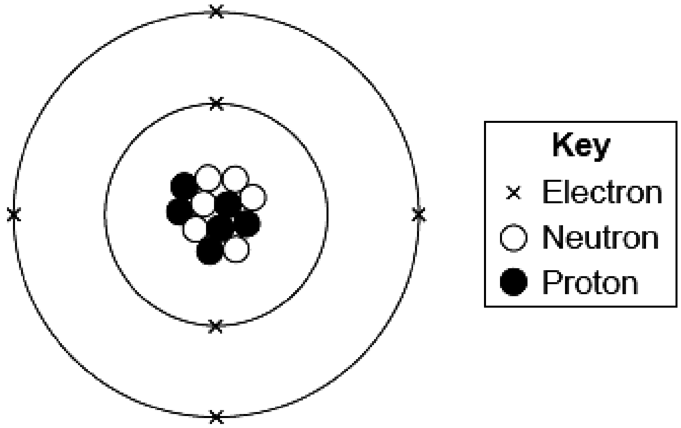
Tick (✓) the **two** statements.

Statement	**Tick (✓)**
The atoms are in layers.	
The metal is shiny.	
The atoms can slide over each other.	
All the atoms are linked by strong covalent bonds.	

(2)

(Total 2 marks)

2 The diagram represents a carbon atom.



(a) Use words from the box to answer the questions.

electron	**neutron**	**nucleus**	**proton**

(i) What is the name of the central part of the atom?

....

(1)

(ii) What is the name of the particle with no charge?

....

(1)

(iii) What is the name of the particle with a negative charge?

....

(1)

(b) Use the diagram above to help you to answer these questions.

(i) Draw a ring around the atomic (proton) number of this carbon atom.

6 **12** **18**

(1)

(ii) Draw a ring around the mass number of this carbon atom.

6 **12** **18**

(1)

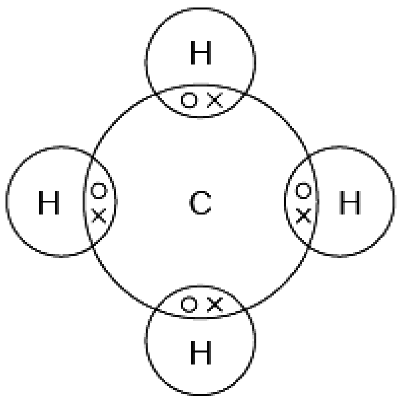
(c) A different carbon atom has 6 protons and 8 neutrons.

Draw a ring around the symbol that represents this atom.

$^{8}_{6}C$ $^{14}_{6}C$ $^{14}_{8}C$

(1)

(d) The diagram shows the bonding in a methane molecule.



(i) Draw a ring around the chemical formula of a methane molecule.

CH_4 **CH^4** **C_4H**

(1)

(ii) Draw a ring around the word that describes methane.

compound **element** **mixture**

(1)

(iii) Draw a ring around the type of bonding in a methane molecule.

covalent **ionic** **metallic**

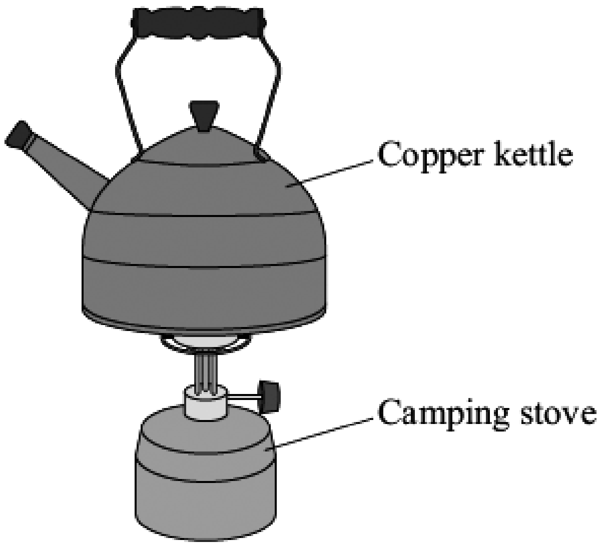
(1)

(Total 9 marks)

3 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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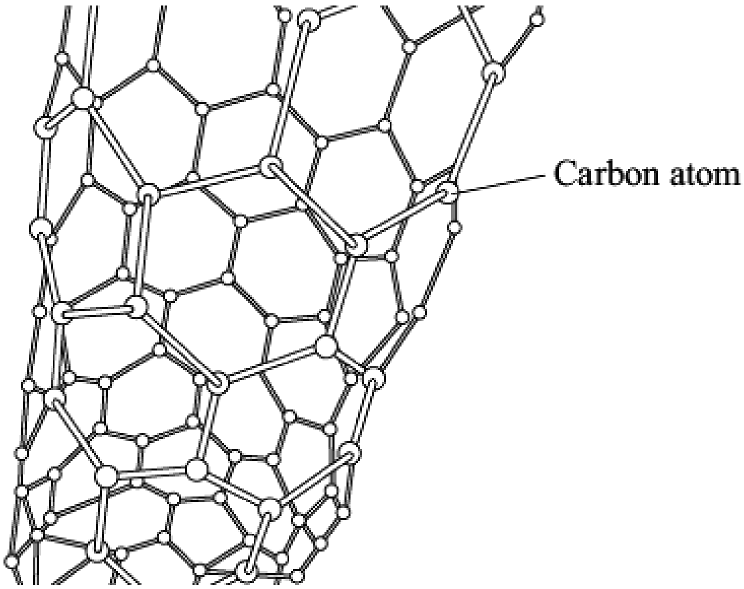
(4)

(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.

....

....

....

....

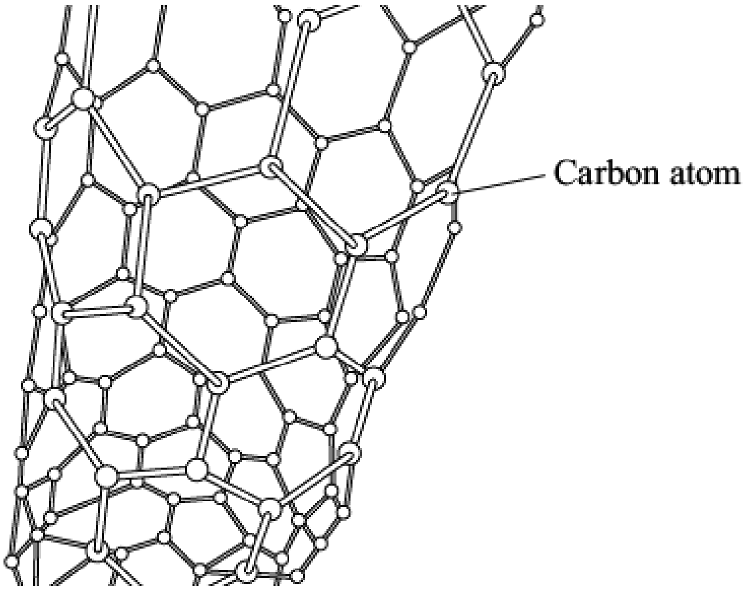
(2)

(Total 7 marks)

4 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 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)

5

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.

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.

(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)

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

The connectors on this scart lead are coated with gold.

(a) Gold is a typical metal.

(i) Describe the structure and bonding of gold.

....

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(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.

....

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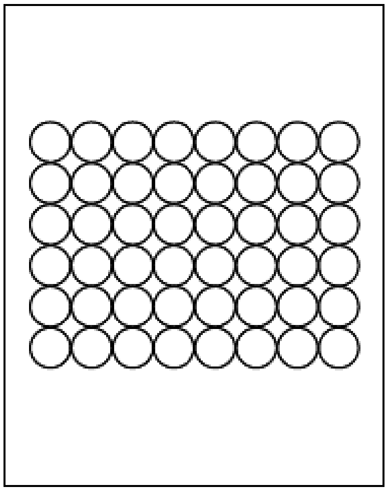
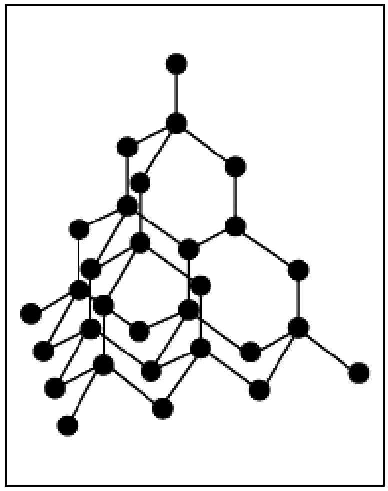
(2)
(Total 6 marks)

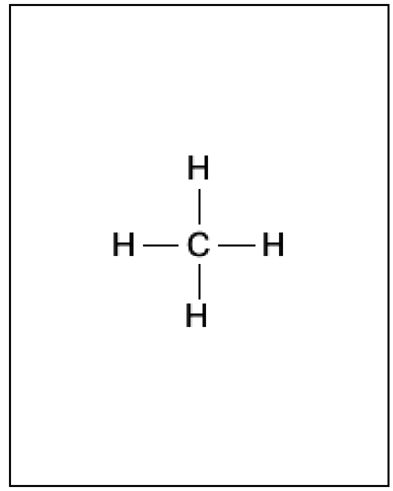
7 The diagrams represent the structures of five substances, **A**, **B**, **C**, **D** and **E**.



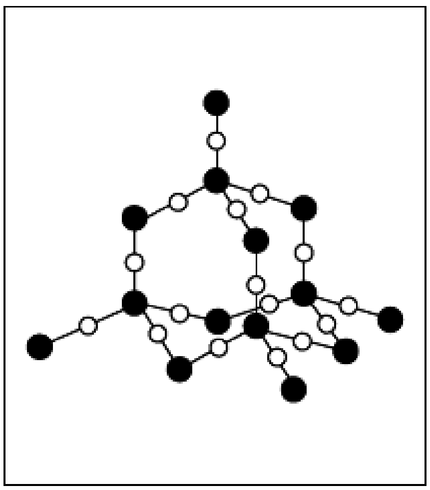
A



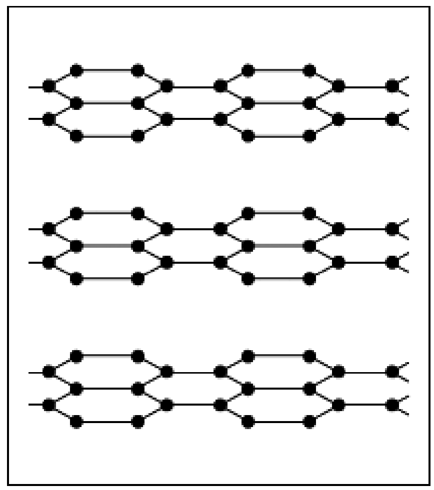
B



C



D



E

(a) Give **one** substance, **A**, **B**, **C**, **D** or **E**, that:

(i) has a very low boiling point

(1)

(ii) is a compound

(1)

(iii) is a metal.

(1)

(b) Draw a ring around the type of bonding holding the atoms together in substance **C**.

covalent **ionic** **metallic**

(1)

(c) Explain why substance **E** is soft and slippery.

....

....

....

....

(2)

(Total 6 marks)

8 Lead compounds have been used for thousands of years as colours in paint.

Johannes Vermeer [Public domain], via Wikimedia Commons

(a) A sample of a red oxide used in paint was found to contain 6.21 g of lead and 0.64 g of oxygen.

Calculate the empirical (simplest) formula of this compound.

You **must** show all your working to gain full marks.

Relative atomic masses: O = 16; Pb = 207.

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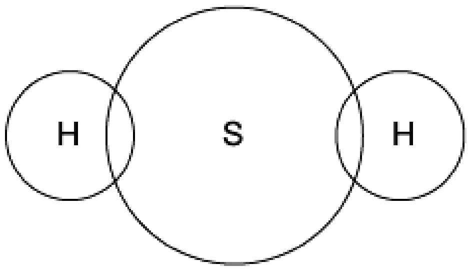
(4)

(b) A problem with lead compounds is that they slowly react with hydrogen sulfide in the air. This produces lead sulfide which is black.

(i) Hydrogen sulfide has the formula H_2S. The bonding in a molecule of hydrogen sulfide can be represented as:

H–S–H

Complete the diagram below to show the arrangement of the outer electrons of the hydrogen and sulfur atoms in hydrogen sulfide.
Use dots (●) and crosses (x) to represent the electrons.
You need only show the outer shell electrons.
(Atomic numbers: H = 1; S = 16.)



(1)

(ii) Hydrogen sulfide has a low boiling point.

Explain why.

....

....

....

....

(2)

(iii) Lead white is also used in paint. The white colour slowly darkens when lead sulfide is produced.

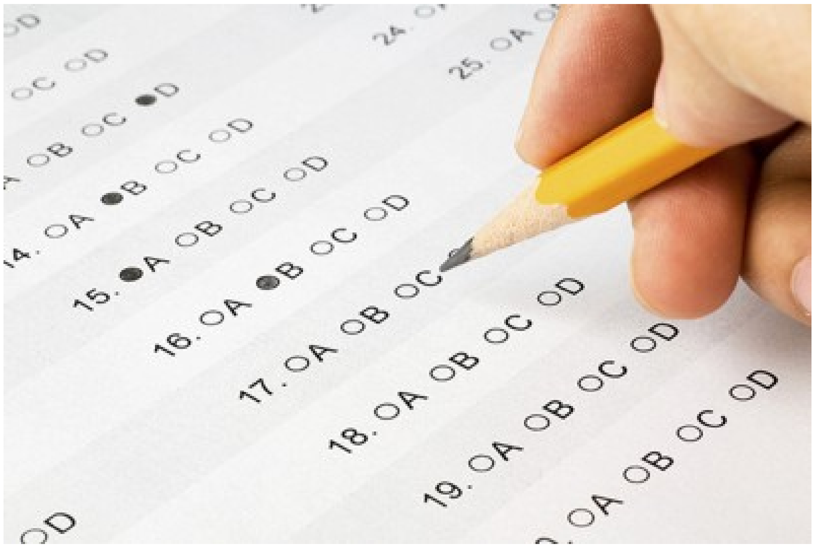
The painting can be restored with hydrogen peroxide. This converts the black lead sulfide into white lead sulfate.

Balance the equation for the reaction between lead sulfide and hydrogen peroxide (H_2O_2).

$$PbS(s) \quad + \quad ....H_2O_2(aq) \quad \rightarrow \quad PbSO_4(s) \quad + \quad 4H_2O(l)$$

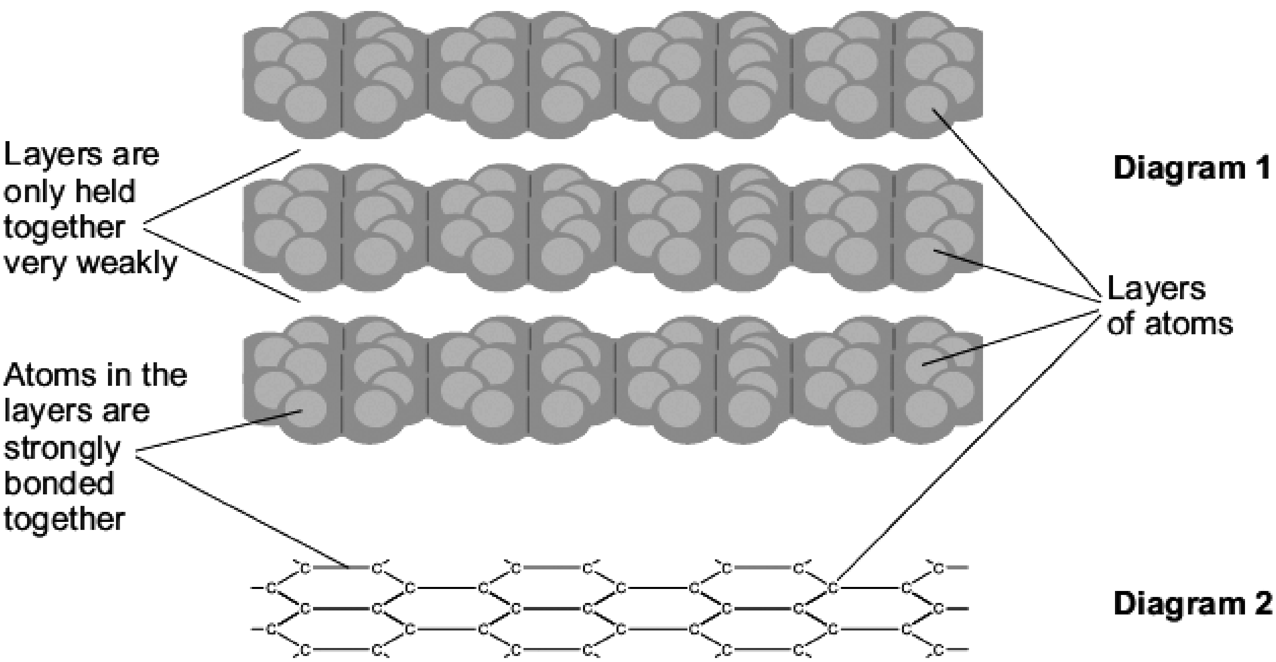
(1)
(Total 8 marks)

9 The picture shows a student using a pencil to complete a multiple choice answer sheet.



The pencil contains graphite. Graphite rubs off the pencil onto the paper.

Diagrams 1 and **2** show how the atoms are arranged in graphite.



(a) Use **Diagram 2** and your Data Sheet to help you to name the element from which graphite is made.

....

(1)

(b) Use **Diagram 1** to help you explain why graphite can rub off the pencil onto the paper.

....

....

....

....

(2)

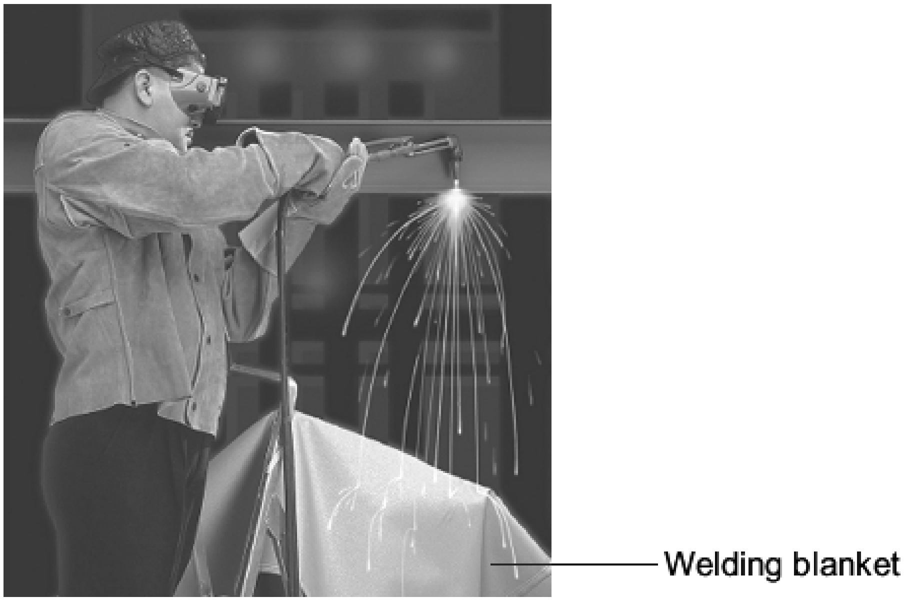
(c) Draw a ring around the type of bond which holds the atoms together in each layer.

covalent **ionic** **metallic**

(1)

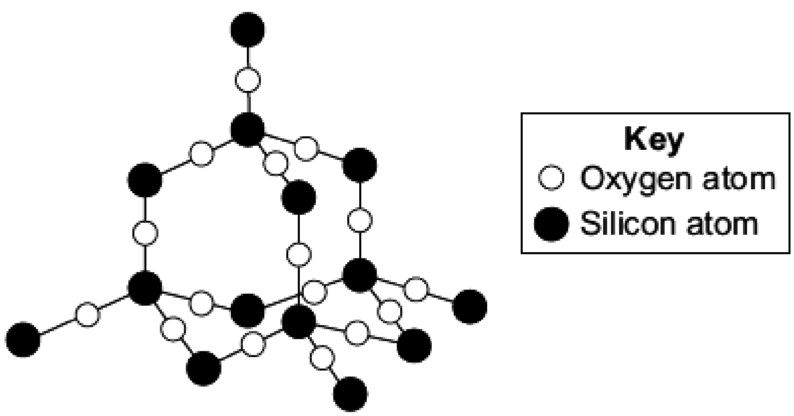
(Total 4 marks)

10 Welding blankets are placed under metals being welded. They protect the area under the welding.



Some welding blankets are made from silicon dioxide which does not melt when hit by sparks or molten metal.

The diagram shows a small part of the structure of silicon dioxide.



Describe the structure and bonding in silicon dioxide **and** explain why it is a suitable material for making welding blankets.

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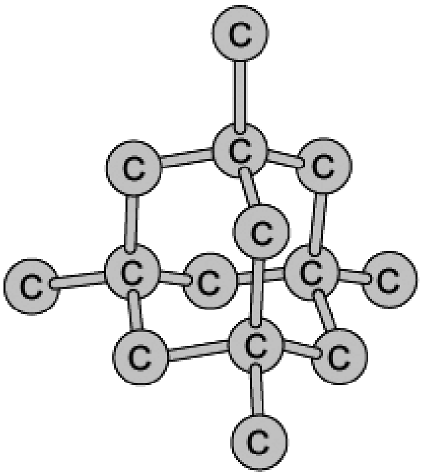
....

(3)
(Total 3 marks)

11 Diamonds are used as abrasives.



Model of part of the diamond structure

Diamonds are very hard.
Explain why.

A good answer will include information on the structure and bonding in diamonds.

....

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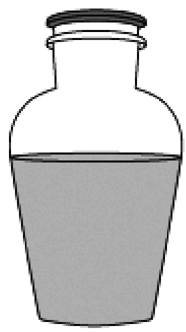
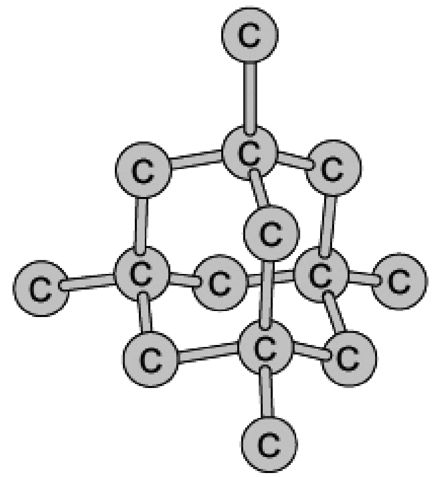
(3)
(Total 3 marks)

12 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.	
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 completete the sentence.

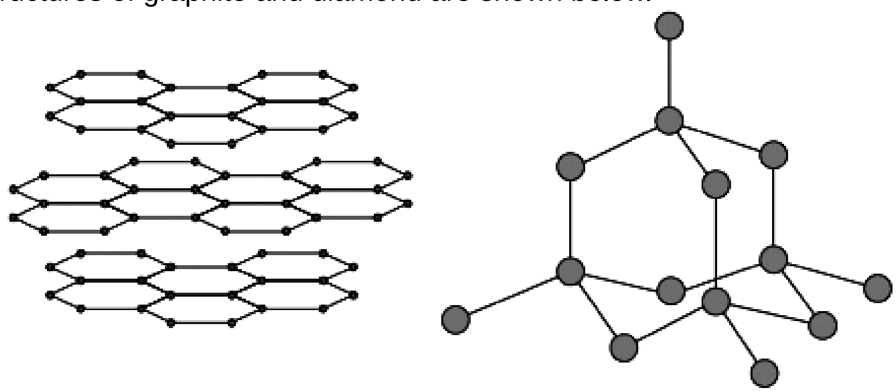
Nanoparticles of diamond are	very small. large. very large.

(1)

(Total 4 marks)

13 Graphite and diamond are different forms of the element carbon.
Graphite and diamond have different properties.

The structures of graphite and diamond are shown below.



Graphite **Diamond**

(a) Graphite is softer than diamond.

Explain why.

....

....

....

....

....

....

....

....

(4)

(b) Graphite conducts electricity, but diamond does not.

Explain why.

....

....

....

....

....

....

(3)

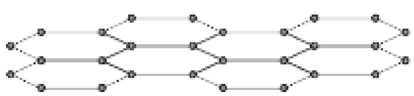
(Total 7 marks)

14 Read the information

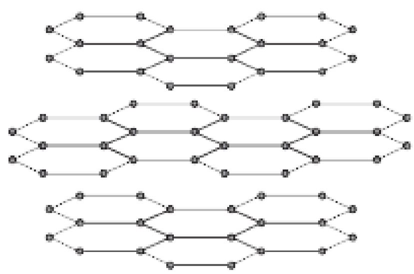
Graphene

Scientists have made a new substance called graphene.
The bonding and structure of graphene are similar to graphite.

Graphene is made of a single layer of the same atoms as graphite.



Graphene



Graphite

Use the information above and your knowledge of graphite to answer the questions.

(a) This part of the question is about graphene.

Choose the correct answer to complete each sentence.

(i)

ionic	**covalent**	**metallic**

The bonds between the atoms in graphene are ....

(1)

(ii)

chromium	**carbon**	**chlorine**

Graphene is made of .... atoms.

(1)

(iii)

2	**3**	**4**

In graphene each atom bonds to .... other atoms.

(1)

(b) This part of the question is about graphite.

Graphite is used in pencils.

Explain why. Use the diagrams to help you.

....

....

....

....

(2)

(Total 5 marks)

15 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.

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

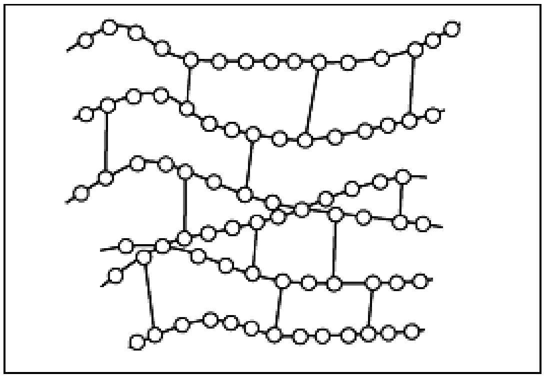
When heated, a thermosoftening polymer will	dissolve. melt. solidify.

(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)

16 This question is about gold (Au).

(a) An atom of gold is represented as:

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

How many neutrons are in this atom of gold? ....

(1)

(b) Gold ions are used as a catalyst.

How does a gold atom (Au) become a gold ion (Au^{3+})?

....

....

....

....

(2)

(c) A gold catalyst can be used when carbon monoxide reacts with oxygen to make carbon dioxide.

(i) Complete and balance the equation for this reaction.

.... CO + ... → ..... CO_2

(2)

(ii) Carbon dioxide has a very low boiling point.

Explain why.

....

....

....

....

....

....

(3)

(d) Gold is used as a catalyst in industrial processes. Gold is rare and increasingly expensive.

Suggest **three** reasons why gold is still used in industrial processes.

....

....

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....

....

(3)
(Total 11 marks)

17 Scientists have recently developed a method to produce large sheets of a substance called graphene.

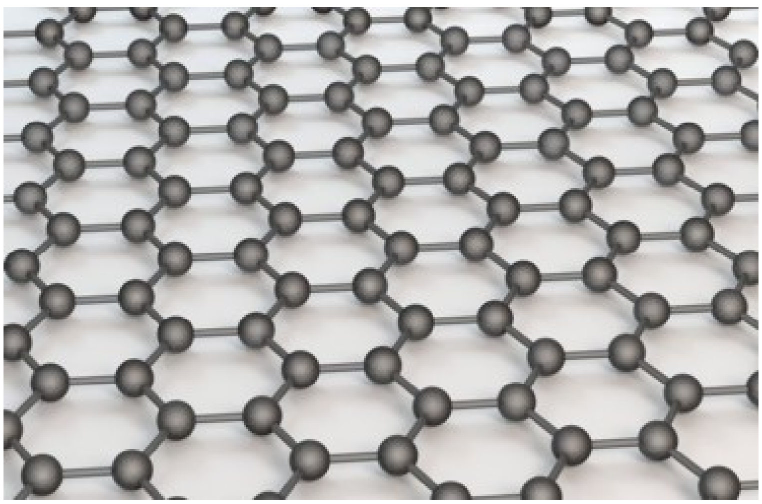
Graphene is made from carbon and is a single layer of graphite just one atom thick.

The properties of graphene include:

- it conducts electricity
- it is transparent since it is only one atom thick
- it is strong and durable.

These properties make it suitable to overlay a monitor screen to make it a touchscreen.

The photograph below shows the structure of graphene.



Photographs supplied by iStockphoto/Thinkstock

Use your knowledge of the bonding in graphite and the photograph of the structure to help you to explain, as fully as you can:

(a) (i) why graphene is strong;

....

....

....

....

....

....

(3)

(ii) why graphene conducts electricity.

....

....

....

....

....

(2)

(b) Suggest why a sheet of graphite which has a large number of carbon layers would not be suitable for the touchscreen.

....

....

(1)

(Total 6 marks)

18 This question is about lithium and sodium.

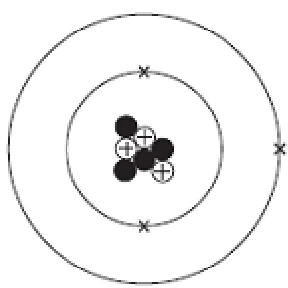
(a) Use the Chemistry Data Sheet to help you to answer this question.

In which group of the periodic table are lithium and sodium? Group [ ]

(1)

(b) A lithium atom can be represented as $^{7}_{3}Li$

The diagram represents the lithium atom.



(i) Some particles in the nucleus have a positive charge.

What is the name of these particles? ....

(1)

(ii) Some particles in the nucleus have no charge.

What is the name of these particles? ....

(1)

(iii) Use the correct answer from the box to complete the sentence.

3	4	7

The mass number of this atom of lithium is ☐

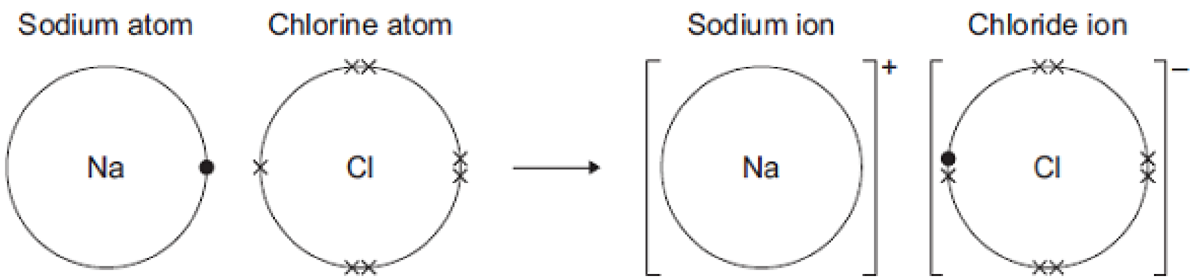
(1)

(c) Sodium reacts with chlorine to produce sodium chloride.

sodium + chlorine ⟶ sodium chloride

The diagram shows how the reaction happens.

Only the outer electrons are shown.



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

(i) A sodium atom changes into a sodium ion by [gaining / losing / sharing] an electron.

(1)

(ii) A sodium ion has [a negative / no / a positive] charge.

(1)

(iii) The ions in sodium chloride are held together by strong [covalent / electrostatic / magnetic] forces.

(1)

(d) Sodium chloride is an ionic compound.

Tick (✓) **two** properties of ionic compounds.

Property	**Tick (✓)**
Do **not** dissolve in water	
High melting points	
Low boiling points	
Strong bonds	

(2)

(e) (i) The formula of sodium chloride is NaCl

Calculate the relative formula mass of sodium chloride.

Relative atomic masses: Na = 23; Cl = 35.5

....

....

Relative formula mass = ...

(1)

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

The relative formula mass of a substance, in grams, is one	ion isotope mole	of the substance.

(1)

(f) Nanoparticles of sodium chloride (salt) are used to flavour crisps.

What are nanoparticles?

....

....

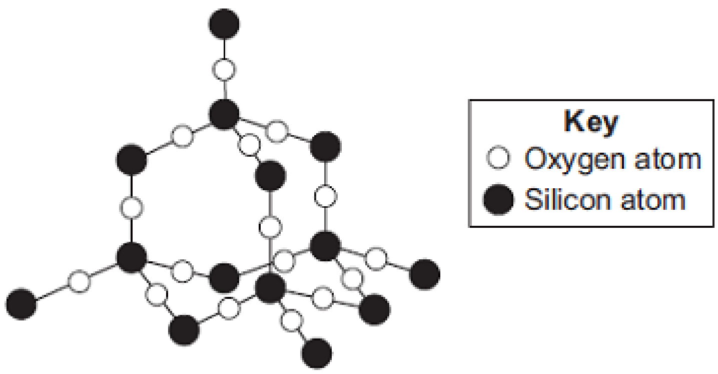
(1)

(Total 12 marks)

19 Silicon dioxide is used as a lining for furnaces.

Furnaces can be used to melt iron for recycling.

The diagram shows a small part of the structure of silicon dioxide.



Explain why silicon dioxide is a suitable material for lining furnaces.

....

....

....

....

....

....

....

....

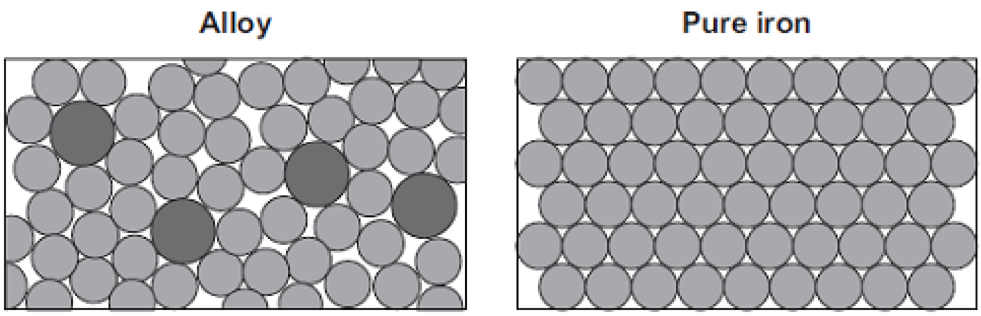
(Total 4 marks)

20 Oil rigs are used to drill for crude oil.

© Digital Vision/Photodisc

(a) Drills are made from an alloy of iron.

The diagrams show the particles in the alloy and in pure iron.



Use the diagrams to explain why the alloy is harder than pure iron.

....

....

....

....

(2)

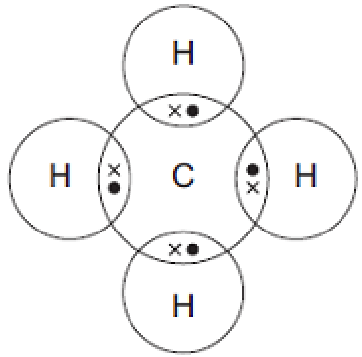
(b) Drill heads contain diamonds.

Tick (✓) **two** reasons why diamonds are hard.

Reason	**Tick (✓)**
Diamonds have a giant covalent structure.	
Diamonds have high melting points.	
Diamonds are unreactive.	
Diamonds have strong bonds between carbon atoms.	

(2)

(c) Methane gas is often found where crude oil is found.
The diagram shows how atoms bond in methane.
Only the outer electrons are shown.



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

Methane is	a compound. an element. a mixture.

(1)

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

The formula of methane is	C_4H_4 C_4H CH_4

(1)

(iii) Name the type of bond between the carbon and hydrogen atoms in methane.

....

(1)

(d) Explain why methane is a gas at 20°C.

....

....

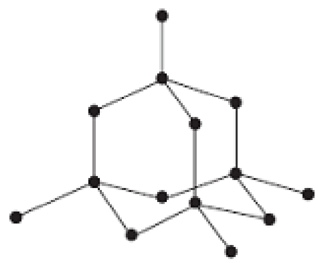
....

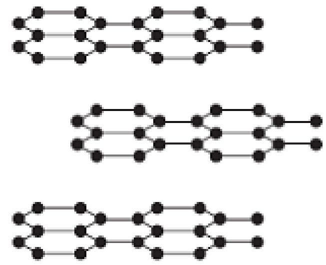
....

(2)

(Total 9 marks)

21 The diagrams show the structures of diamond and graphite.





Diamond **Graphite**

(a) Diamond and graphite both contain the same element.

What is the name of this element? ....

(1)

(b) Use the diagrams above and your knowledge of structure and bonding to explain why:

(i) graphite is very soft

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....

....

(2)

(ii) diamond is very hard

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(2)

(iii) graphite conducts electricity.

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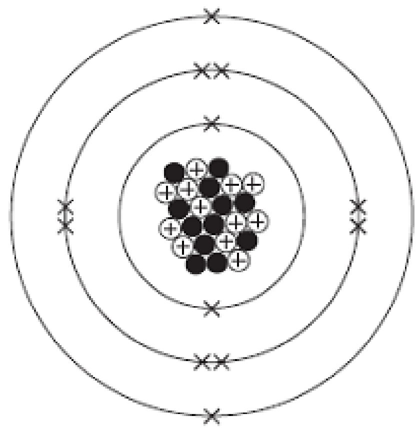
(2)

(Total 7 marks)

22 The diagram represents a magnesium atom.



(a) Use words from the box to answer these questions.

electron	**neutron**	**nucleus**	**proton**

(i) What is the name of the central part of the atom? ....

(1)

(ii) What is the name of the particle with no charge? ....

(1)

(iii) What is the name of the particle with a negative charge? ....

(1)

(b) Use the diagram above to help you answer these questions.

(i) Draw a ring around the atomic (proton) number of this magnesium atom.

12 **24** **36**

(1)

(ii) Draw a ring around the mass number of this magnesium atom.

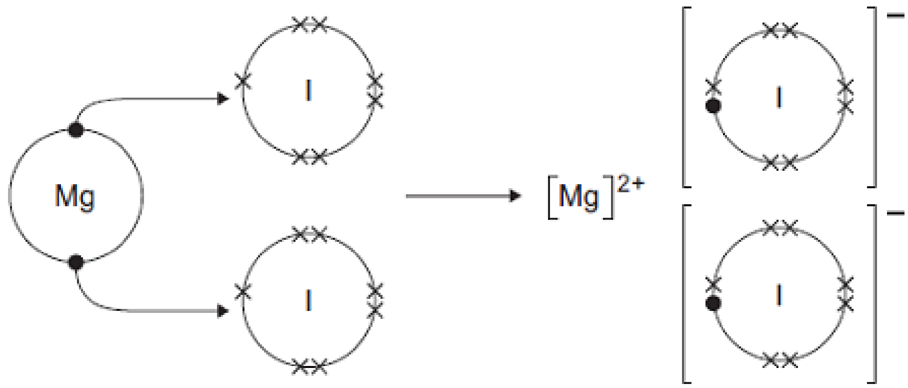
12 **24** **36**

(1)

(c) The diagram shows how magnesium and iodine atoms form magnesium iodide.

Only the outer electrons are shown.

The dots (●) and crosses (×) are used to represent electrons.



Use the diagram to help you to answer this question.

Describe, as fully as you can, what happens when magnesium reacts with iodine to make magnesium iodide.

To gain full marks you should use the words atom, electron and ion in your answer.

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(4)

(Total 9 marks)

23 This question is about some compounds made from iodine.

(a) Lead iodide can be made by mixing a solution containing lead ions with a solution containing iodide ions. Lead iodide is formed as a precipitate.

$$Pb^{2+}(aq) \quad + \quad 2I^{-}(aq) \longrightarrow PbI_2\,(s)$$

The table below gives information about the solubility of some compounds.

Soluble compounds	Insoluble compounds
All sodium and potassium salts	
All nitrates	
Most chlorides, bromides and iodides	Silver and lead chlorides, bromides and iodides

Use the table to help you to name:

(i) A soluble compound which contains lead ions ....

(1)

(ii) A soluble compound which contains iodide ions ....

(1)

(b) Magnesium iodide can be made by reacting magnesium with iodine.

$$Mg + I_2 \longrightarrow MgI_2$$

Magnesium iodide is an ionic compound. It contains magnesium ions (Mg^{2+}) and iodide ions (I^-).

Describe, in terms of electrons, what happens when magnesium reacts with iodine.

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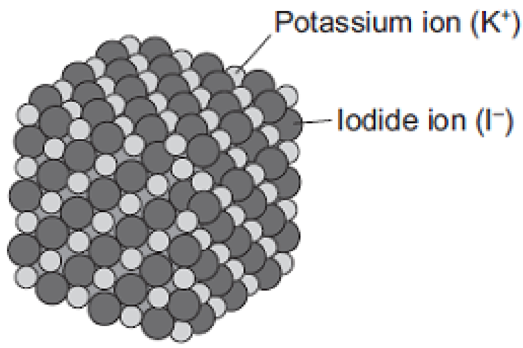
(4)

(c) The diagram shows the structure of potassium iodide.



Explain why a high temperature is needed to melt potassium iodide.

....

....

....

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....

....

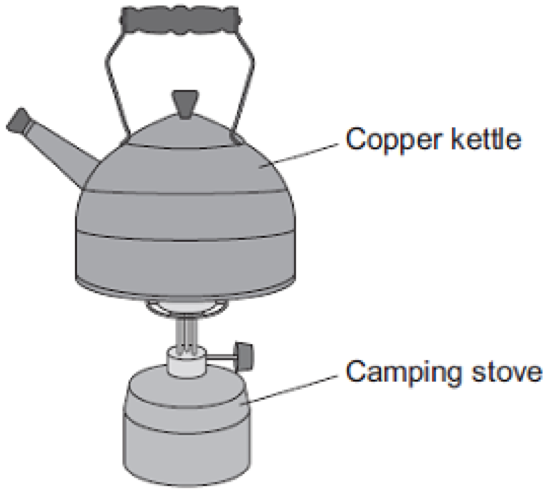
(3)

(Total 9 marks)

24 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.

....

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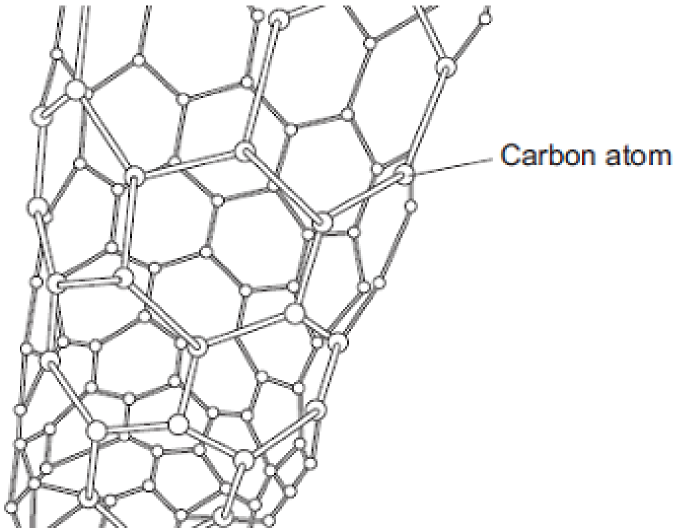
(4)

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

Explain why the carbon nanotube can conduct electricity.

....

....

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....

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(2)

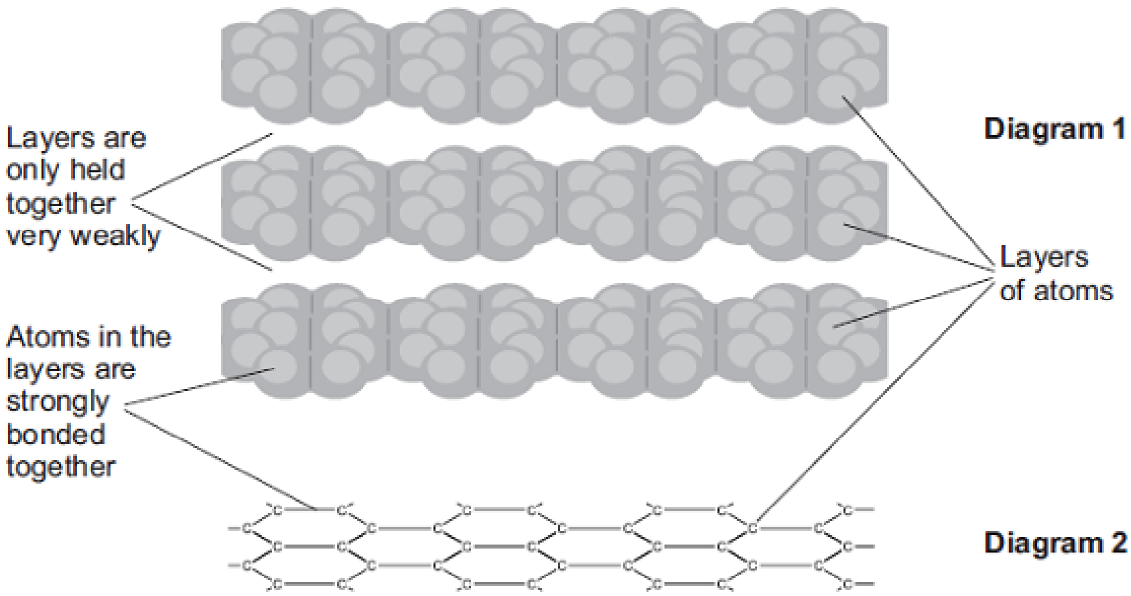
(Total 7 marks)

25 The picture shows a student filling in a multiple choice answer sheet using a pencil.

© Cihan Ta?k?n/iStock

The pencil contains graphite. Graphite rubs off the pencil onto the paper.

Diagrams **1** and **2** show how the atoms are arranged in graphite.



(a) Use the diagrams to help you explain why graphite can rub off the pencil onto the paper.

....

....

....

....

(2)

(b) Draw a ring around the type of bond which holds the atoms together in each layer.

covalent **ionic** **metallic**

(1)
(Total 3 marks)

26 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.

'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.

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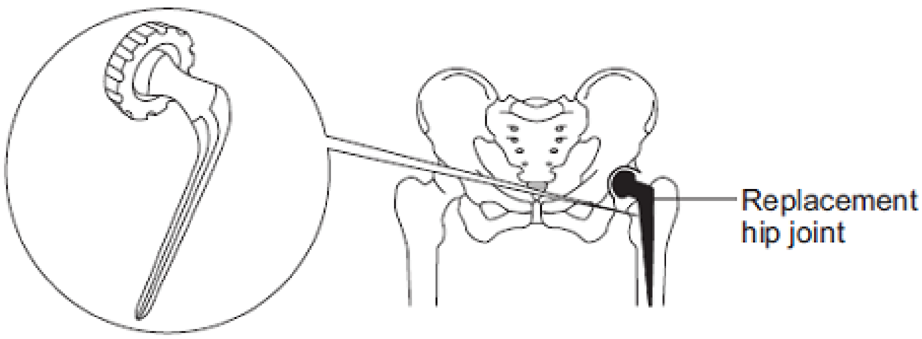
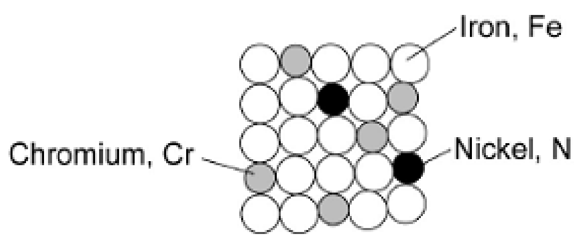
(2)

(Total 3 marks)

27 The hip joint sometimes has to be replaced.
Early replacement hip joints were made from stainless steel.



Stainless steel is an alloy of iron, chromium and nickel.
The diagram below represents the particles in stainless steel.



Paticle diagram of stainless steal

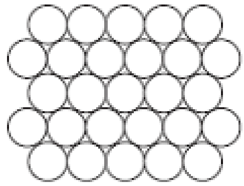
(a) Use the diagram to complete the percentages of metals in this stainless steel.

The first one has been done for you.

Element	**Percentage (%)**
Iron, Fe	72
Chromium, Cr	
Nickel, Ni	

(2)

(b) Pure iron is a soft, metallic *element*.



(i) Why is iron described as an *element*?

....

....

(1)

(ii) Pure iron would **not** be suitable for a replacement hip joint.

Suggest why.

....

....

(1)

(iii) The three metals in stainless steel have different sized atoms.
Stainless steel is harder than pure iron.

Explain why.

....

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....

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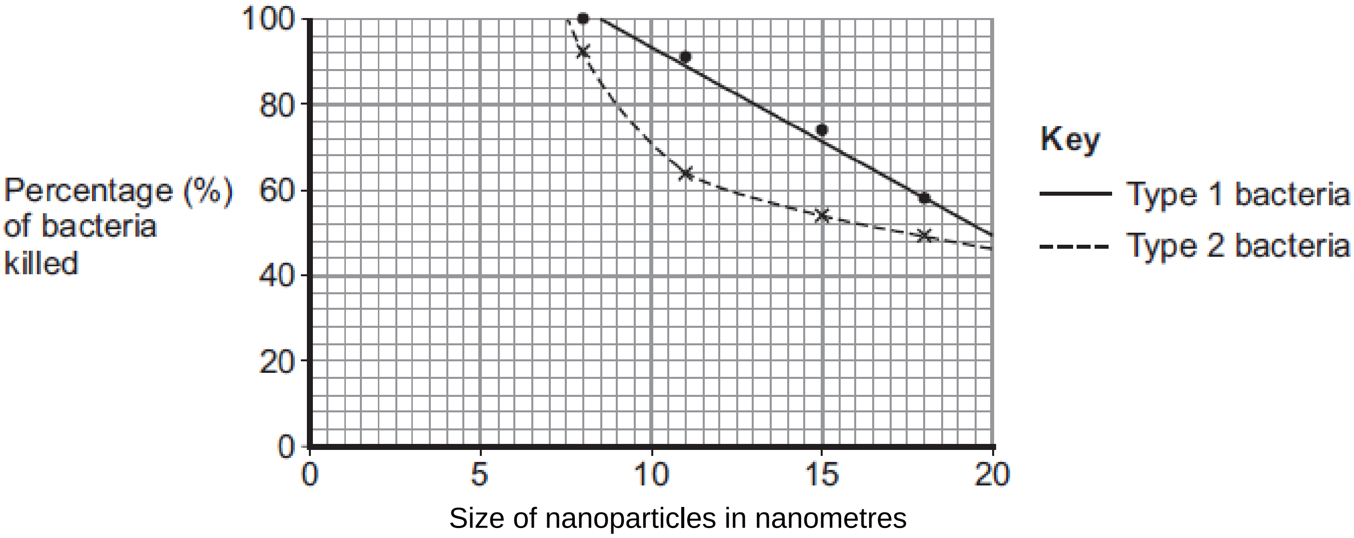
(2)

(Total 6 marks)

28 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.

....

....

....

....

....

....

(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.

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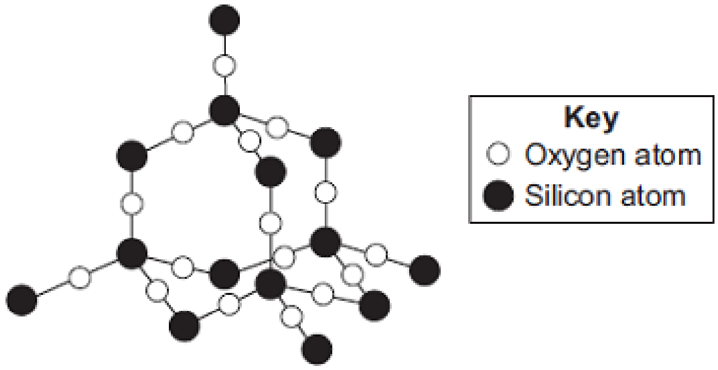
(4)

(Total 7 marks)

29

The diagram shows a small part of the structure of silicon dioxide.



(a) Use the diagram above to answer the question.

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

In silicon dioxide, each silicon atom is bonded with [two / three / four] oxygen atoms.

	two	
In silicon dioxide, each silicon atom is bonded with	three	oxygen atoms.
	four	

	ionic.
The bonds in silicon dioxide are	covalent.
	metallic.

(2)

(b)

© Oleksiy Mark/iStock

Silicon dioxide is used as the inside layer of furnaces.

Suggest why.

....

....

(1)

(c) Nanowires can be made from silicon dioxide.

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

The word 'nano' means the wires are very	brittle. thick. thin.

(1)
(Total 4 marks)

30 Glass is made from silicon dioxide.

© Velirina/iStock/Thinkstock

(a) Silicon dioxide has a very high melting point.

Other substances are added to silicon dioxide to make glass. Glass melts at a lower temperature than silicon dioxide.

Suggest why.

....

....

(1)

(b) Sodium oxide is one of the substances added to silicon dioxide to make glass.

(i) Sodium oxide contains Na^+ ions and O^{2-} ions.

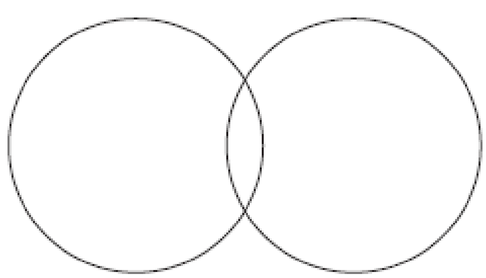
Give the formula of sodium oxide.

....

(1)

(ii) Sodium oxide is made by heating sodium metal in oxygen gas.

Complete the diagram to show the outer electrons in an oxygen molecule (O_2).



(2)

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

Describe the structure of a metal.

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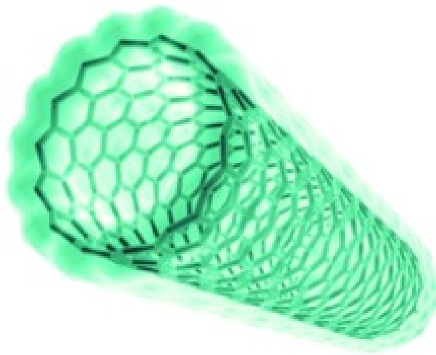
(3)

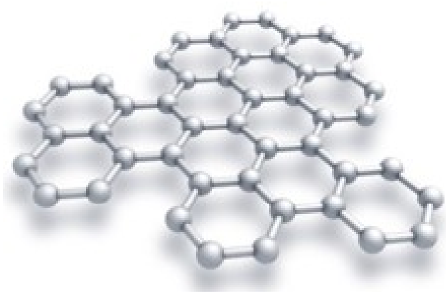
(Total 7 marks)

31 Carbon atoms are used to make nanotubes.



Carbon atoms in a nanotube are bonded like a single layer of graphite.

The figure below shows the structure of a single layer of graphite.



(a) Suggest why carbon nanotubes are used as lubricants.

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....

(2)

(b) Explain why graphite can conduct electricity.

....

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....

....

(2)

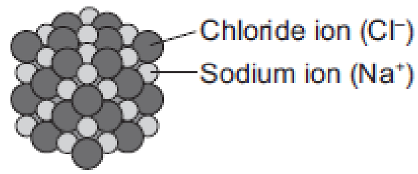
(Total 4 marks)

32 **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Explain why chlorine (Cl_2) is a gas at room temperature, but sodium chloride (NaCl) is a solid at room temperature.

Chlorine | **Sodium chloride**

Cl — Cl



Include a description of the bonding and structure of chlorine and sodium chloride in your answer.

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....

Extra space ....

....

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....

....

(Total 6 marks)

33 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

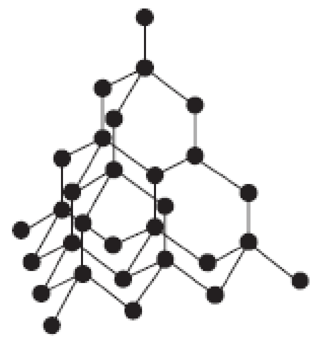
(1)

(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.



(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)

34 This question is about atoms.

Atoms contain electrons, neutrons and protons.

(a) (i) Which of these particles has a positive charge?

Tick (✓) **one** box.

Electron ☐

Neutron ☐

Proton ☐

(1)

(ii) Which of these particles does **not** have an electrical charge?

Tick (✓) **one** box.

Electron ☐

Neutron ☐

Proton ☐

(1)

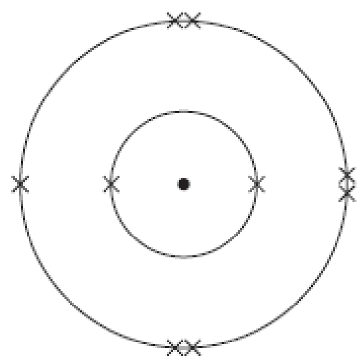
(b) How are the elements in the periodic table arranged?

Tick (✓) **one** box.

In order of increasing atomic number	☐
In order of increasing mass number	☐
In order of increasing reactivity	☐

(1)

(c) The diagram shows the arrangement of the electrons in an atom of fluorine.



(i) How many protons are in an atom of fluorine?

Tick (✓) **one** box.

2	☐
7	☐
9	☐

(1)

(ii) The boiling point of fluorine is −188 °C.

What is the state of fluorine at room temperature?

Tick (✓) **one** box.

Solid ☐

Liquid ☐

Gas ☐

(1)

(d) Fluorine reacts with copper to form an ionic compound.

(i) Explain, in terms of electrons and electronic structure, what happens to a fluorine atom when it reacts with copper.

Use Above **Figure** to help you to answer this question.

....

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....

(2)

(ii) Describe a chemical test which would show that a solution contains copper(II) ions.

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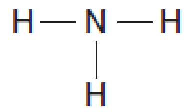
(2)

(Total 9 marks)

35

(a) A particle of ammonia is represented by the formula NH_3 or as:



(i) How many different elements are there in a particle of ammonia?

....

(1)

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

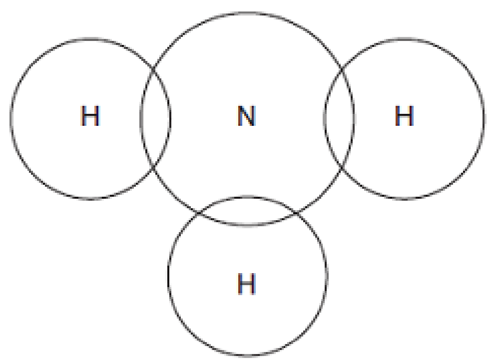
A particle of ammonia is called

an atom.
an ion.
a molecule.

(1)

(iii) Complete the dot and cross bonding diagram for ammonia.

Show **only** electrons in the outer energy level of each atom.



(2)

(b) Ammonia gas reacts with hydrogen chloride gas to produce a white solid.

The formula of the white solid is NH_4Cl

(i) Complete the equation by adding the correct state symbols.

NH_3(g) + HCl(........) ⟶ NH_4Cl(........)

(1)

(ii) The white solid has the formula NH_4Cl

Complete the name of the white solid.

Ammonium ....

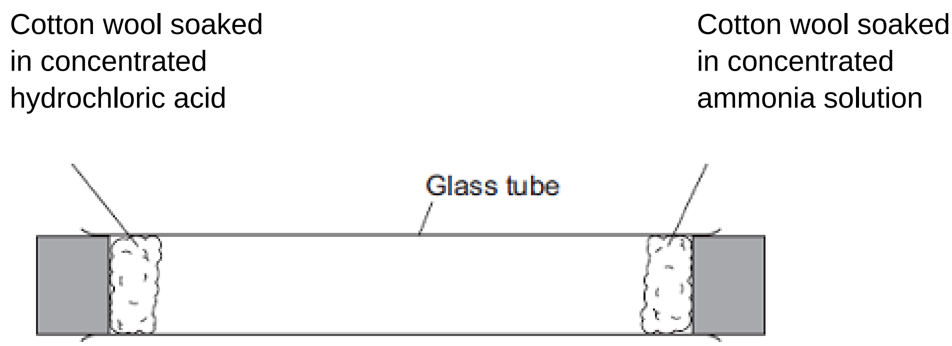
(1)

(c) Concentrated ammonia solution gives off ammonia gas.

Concentrated hydrochloric acid gives off hydrogen chloride gas.

Apparatus was set up as shown in **Diagram 1**.

Diagram 1



(i) Concentrated hydrochloric acid is corrosive.

Give **one** safety precaution you should take when using concentrated hydrochloric acid.

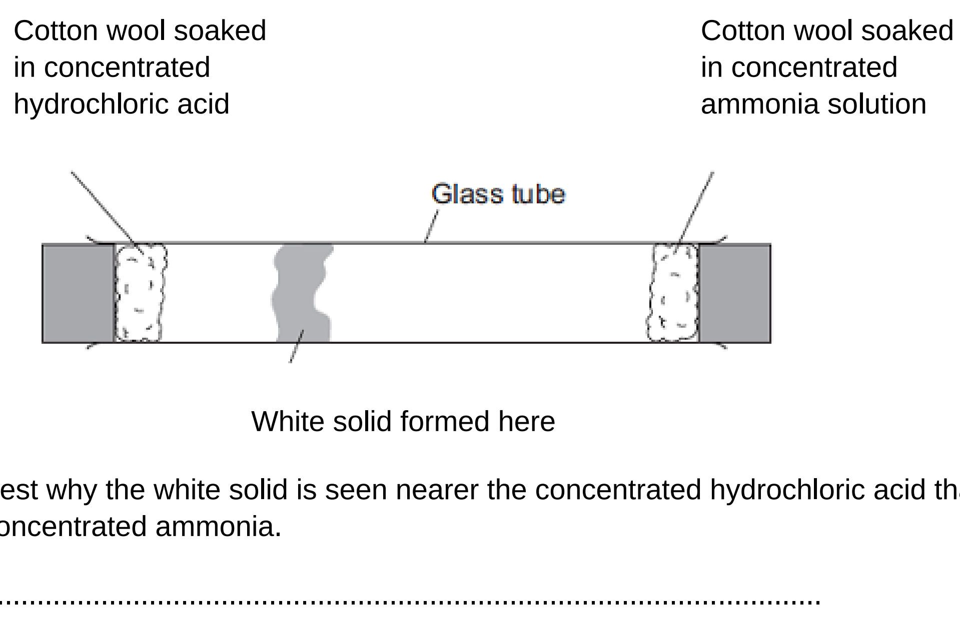
....

....

(1)

(ii) After 3 minutes a white solid was seen in the glass tube, as shown in **Diagram 2**.

Diagram 2



Suggest why the white solid is seen nearer the concentrated hydrochloric acid than the concentrated ammonia.

....

....

(1)

(iii) The experiment was repeated at a higher temperature.

Explain why the white solid was produced in less than 3 minutes.

....

....

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....

(2)

(Total 10 marks)

36 This question is about sodium chloride and iodine.

(a) Describe the structure and bonding in sodium chloride.

....

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....

(4)

(b) When sodium chloride solution is electrolysed, one product is chlorine.

Name the **two** other products from the electrolysis of sodium chloride solution.

....

....

(2)

(c) Many people do not have enough iodine in their diet.

Sodium chloride is added to many types of food. Some scientists recommend that sodium chloride should have a compound of iodine added.

Give **one** ethical reason why a compound of iodine should **not** be added to sodium chloride used in food.

....

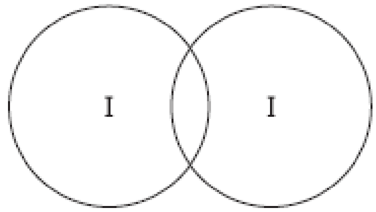
....

(1)

(d) The bonding in iodine is similar to the bonding in chlorine.

(i) Complete the diagram below to show the bonding in iodine.

Show the outer electrons only.



(2)

(ii) Explain why iodine has a low melting point.

....

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(3)

(iii) Explain, in terms of particles, why liquid iodine does not conduct electricity.

....

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....

(2)

(Total 14 marks)

37 The article gives some information about graphene.

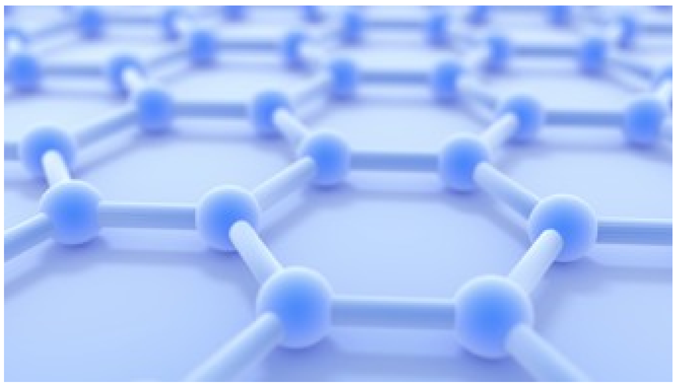
Nanotunes!

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.

The picture shows the structure of graphene.



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

(i) explain why graphene is strong;

....

....

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....

....

(3)

(ii) explain why graphene can conduct electricity.

....

....

....

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(2)

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

Explain why graphite is a lubricant.

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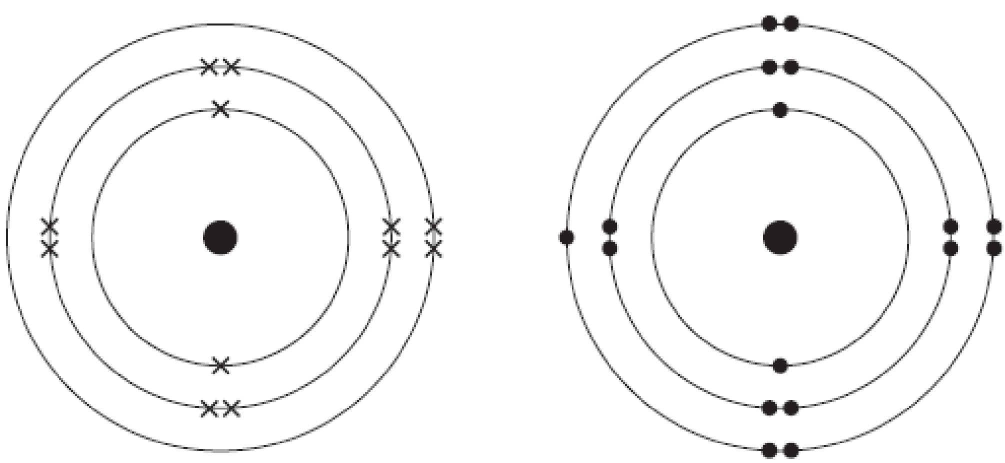
....

(2)

(Total 7 marks)

38 (a) The diagram shows an atom of magnesium and an atom of chlorine.



Magnesium **Chlorine**

Describe, in terms of electrons, how magnesium atoms and chlorine atoms change into ions to produce magnesium chloride ($MgCl_2$).

....

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....

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....

(4)

(b) Calculate the relative formula mass (M_r) of magnesium chloride ($MgCl_2$).

Relative atomic masses (A_r): magnesium = 24; chlorine = 35.5

....

....

....

Relative formula mass (M_r) = ...

(2)

(Total 6 marks)

39 This question is about different substances and their structures.

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

Statement

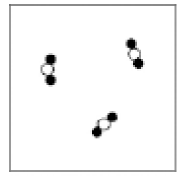
The substance is a gas

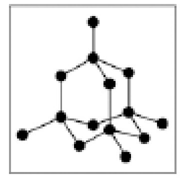
The substance is a liquid

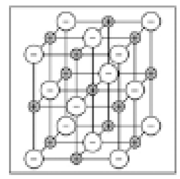
The substance is ionic

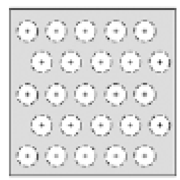
The substance is a solid metal

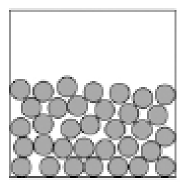
Structure







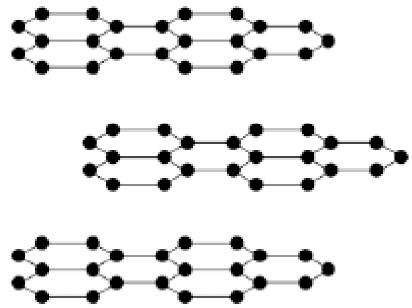




(4)

(b) **Figure 1** shows the structure of an element.

Figure 1



What is the name of this element?

Tick **one** box.

Carbon ☐

Chloride ☐

Nitrogen ☐

Xenon ☐

(1)

(c) Why does this element conduct electricity?

Tick **one** box.

It has delocalised electrons ☐

It contains hexagonal rings ☐

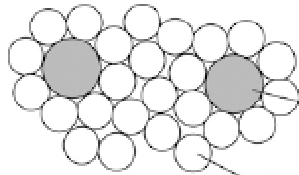
It has weak forces between the layers ☐

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)

40 This question is about metals and alloys.

(a) Explain how electricity is conducted in a metal.

To gain full marks you must include a description of the structure and bonding of a metal.

....

....

....

....

....

....

....

....

(4)

(b) Describe how the structure of an alloy is different from the structure of a pure metal.

....

....

....

....

(2)

(c) Alloys are used to make dental braces and coins.

(i) Nitinol is an alloy used in dental braces.

Why is Nitinol used in dental braces?

....

....

(1)

(ii) Suggest **one** reason why coins are not made of pure copper.

Do **not** give cost as a reason.

....

....

(1)

(iii) Some coins are made from an alloy of aluminium.

Complete the sentence.

Aluminium is manufactured by the electrolysis of a molten mixture of cryolite and

....

(1)

(iv) Banks keep coins in poly(ethene) bags. These bags are made from low density poly(ethene).

High density poly(ethene) can also be made from the same monomer.

How can the same reaction produce two different products?

....

....

(1)

(d) Give **two** reasons why instrumental methods of analysis are used to detect impurities in metals.

....

....

....

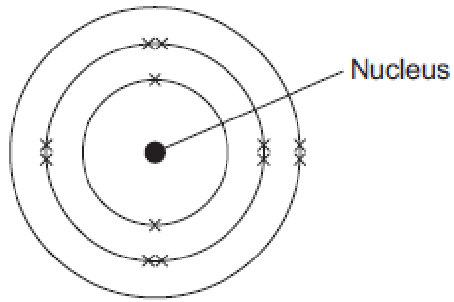
(1)

(Total 11 marks)

41

This question is about magnesium.

(a) (i) The electronic structure of a magnesium atom is shown below.



Use the correct answer from the box to complete each sentence.

electrons	**neutrons**	**protons**	**shells**

The nucleus contains protons and ....

The particles with the smallest relative mass that move around the nucleus are called ....

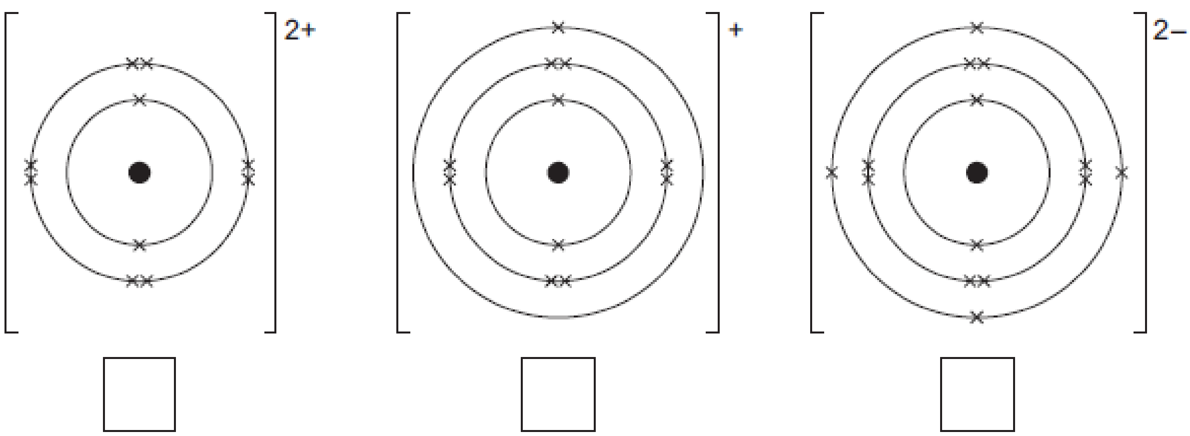
Atoms of magnesium are neutral because they contain the same number of electrons and ....

(3)

(ii) A magnesium atom reacts to produce a magnesium ion.

Which diagram shows a magnesium ion?

Tick (✓) **one** box.



(1)

(b) Magnesium and dilute hydrochloric acid react to produce magnesium chloride solution and hydrogen.

$$Mg(s) + 2\ HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$$

(i) State **two** observations that could be made during the reaction.

1 ....

....

2 ....

....

(2)

(ii) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Describe a method for making pure crystals of magnesium chloride from magnesium and dilute hydrochloric acid.

In your method you should name the apparatus you will use.

You do **not** need to mention safety.

....

....

....

....

....

....

....

....

....

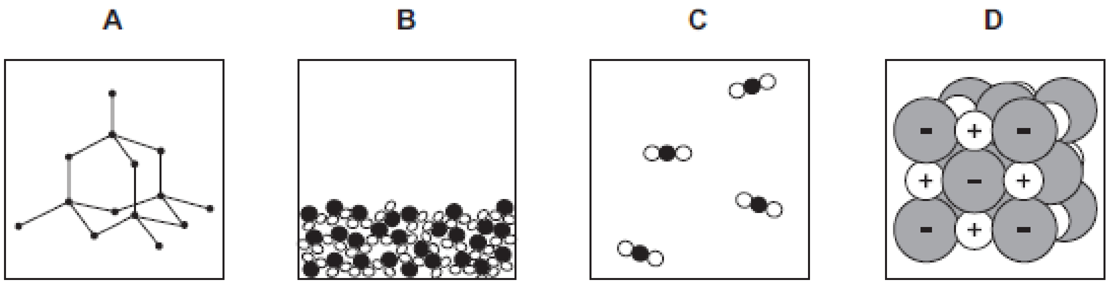
....

(6)

(Total 12 marks)

42 The structures of four substances, **A**, **B**, **C** and **D**, are represented in **Figure 1**.

Figure 1



(a) Use the correct letter, **A**, **B**, **C** or **D**, to answer each question.

(i) Which substance is a gas? ☐

(1)

(ii) Which substance is a liquid? ☐

(1)

(iii) Which substance is an element? ☐

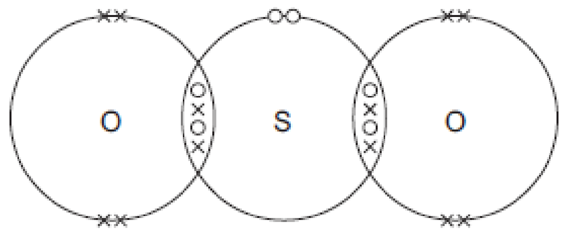
(1)

(iv) Which substance is made of ions? ☐

(1)

(b) **Figure 2** shows the bonding in substance **C**.

Figure 2



(i) What is the formula of substance **C**?

Draw a ring around the correct answer.

SO_2 **SO^2** **S_2O**

(1)

(ii) Use the correct answer from the box to complete the sentence.

delocalised	**shared**	**transferred**

When a sulfur atom and an oxygen atom bond to produce substance **C**,

electrons are ....

(1)

(iii) What is the type of bonding in substance **C**?

Draw a ring around the correct answer.

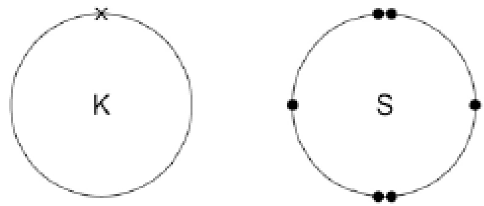
covalent **ionic** **metallic**

(1)

(Total 7 marks)

43 **Figure 1** shows the outer electrons in an atom of the Group 1 element potassium and in an atom of the Group 6 element sulfur.

Figure 1



(a) Potassium forms an ionic compound with sulfur.

Describe what happens when **two** atoms of potassium react with **one** atom of sulfur.

Give your answer in terms of electron transfer.

Give the formulae of the ions formed.

....

....

....

....

....

....

....

....

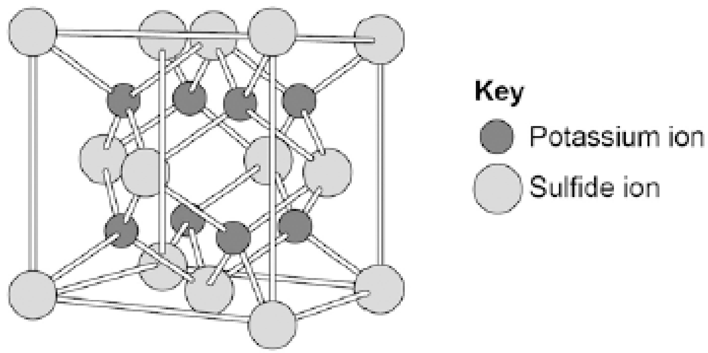
....

....

(5)

(b) The structure of potassium sulfide can be represented using the ball and stick model in **Figure 2**.

Figure 2



The ball and stick model is **not** a true representation of the structure of potassium sulfide.

Give **one** reason why.

....

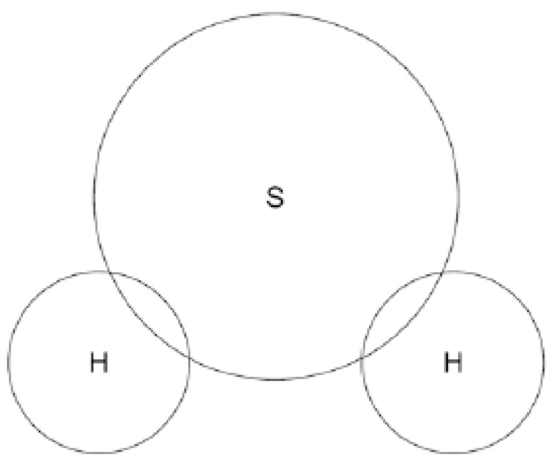
....

(1)

(c) Sulfur can also form covalent bonds.

Complete the dot and cross diagram to show the covalent bonding in a molecule of hydrogen sulfide.

Show the outer shell electrons only.



(2)

(d) Calculate the relative formula mass (M_r) of aluminium sulfate $Al_2(SO_4)_3$

Relative atomic masses (A_r): oxygen = 16; aluminium = 27; sulfur = 32

....

....

....

Relative formula mass = ...

(2)

(e) Covalent compounds such as hydrogen sulfide have low melting points and do **not** conduct electricity when molten.

Draw **one** line from each property to the explanation of the property.

Property	**Explanation of property**
	Electrons are free to move
	There are no charged particles free to move
Low melting point	
	Ions are free to move
	Weak intermolecular forces of attraction
Does not conduct electricity when molten	
	Bonds are weak
	Bonds are strong

(2)

(f) Ionic compounds such as potassium sulfide have high boiling points and conduct electricity when dissolved in water.

Draw **one** line from each property to the explanation of the property.

Property	**Explanation of property**
	Electrons are free to move
	There are no charged particles free to move
High boiling point	
	Ions are free to move
	Weak intermolecular forces of attraction
Conduct electricity when molten	
	Bonds are weak
	Bonds are strong

(2)

(Total 14 marks)

44 This question is about the properties and uses of materials.

Use your knowledge of structure and bonding to answer the questions.

(a) Explain how copper conducts electricity.

....

....

....

....

....

(2)

(b) Explain why diamond is hard.

....

....

....

....

....

(2)

(c) Explain why thermosetting polymers are better than thermosoftening polymers for saucepan handles.

....

....

....

....

....

(2)

(Total 6 marks)

45

The table below gives information about four alcohols.

Alcohol	Formula	Melting point in °C	Boiling point in °C
Methanol	CH_3OH	−94	65
Ethanol	CH_3CH_2OH	−118	78
Propanol	$CH_3CH_2CH_2OH$	−129	97
Butanol	$CH_3CH_2CH_2CH_2OH$	−89	118

(a) Which alcohol in the table is liquid over the greatest temperature range?

....

(1)

(b) Which statement is correct?

Tick **one** box.

A molecule of ethanol has 5 hydrogen atoms ☐

Butanol has the highest boiling point ☐

Methanol has the largest molecules ☐

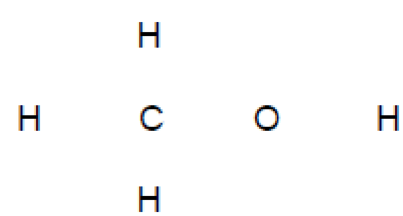
Propanol has the highest melting point ☐

(1)

(c) A molecule of methanol has five single covalent bonds.

Draw the missing bonds in **Figure 1** to complete the displayed formula for methanol.

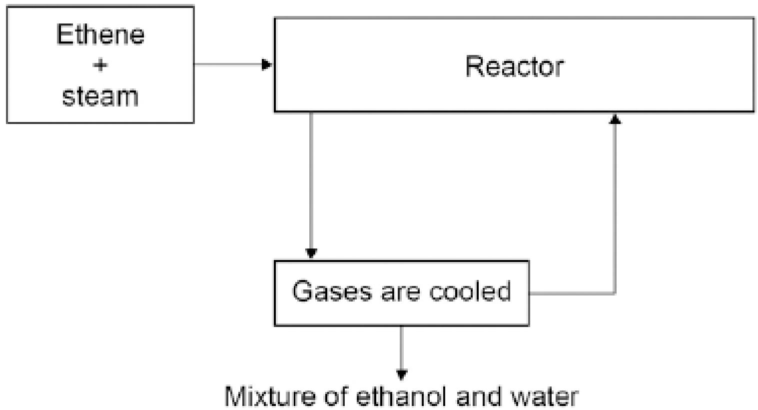
Figure 1



(1)

(d) **Figure 2** shows a flow diagram of the process to produce ethanol.

Figure 2



Complete the word equation for the reaction to produce ethanol.

.... + ... → ethanol

(1)

(e) What happens to the unreacted ethene?

....

....

(1)

(f) Wine contains ethanol.
A bottle of wine was left open in air.
After a few days, the wine tasted of vinegar.
Vinegar is a solution of ethanoic acid in water.

Explain how oxidation causes the wine to taste of vinegar after a few days.

....

....

....

....

....

....

....

....

(3)
(Total 8 marks)

46 This question is about halogens and their compounds.

The table below shows the boiling points and properties of some of the elements in Group 7 of the periodic table.

Element	**Boiling point in °C**	**Colour in aqueous solution**
Fluorine	−188	colourless
Chlorine	−35	pale green
Bromine	X	orange
Iodine	184	brown

(a) Why does iodine have a higher boiling point than chlorine?

Tick **one** box.

Iodine is ionic and chlorine is covalent ☐

Iodine is less reactive than chlorine ☐

The covalent bonds between iodine atoms are stronger ☐

The forces between iodine molecules are stronger ☐

(1)

(b) Predict the boiling point of bromine.

....

(1)

(c) A redox reaction takes place when aqueous chlorine is added to potassium iodide solution.

The equation for this reaction is:

$$Cl_2(aq) + 2KI(aq) \rightarrow I_2(aq) + 2KCl(aq)$$

Look at table above.

What is the colour of the final solution in this reaction?

Tick **one** box.

Brown ☐

Orange ☐

Pale green ☐

Colourless ☐

(1)

(d) What is the ionic equation for the reaction of chlorine with potassium iodide?

Tick **one** box.

$Cl_2 + 2K \rightarrow 2KCl$ ☐

$2I^- + Cl_2 \rightarrow I_2 + 2Cl^-$ ☐

$I^- + Cl \rightarrow I + Cl^-$ ☐

$I^- + K^+ \rightarrow KI$ ☐

(1)

(e) Why does potassium iodide solution conduct electricity?

Tick **one** box.

It contains a metal	☐
It contains electrons which can move	☐
It contains ions which can move	☐
It contains water	☐

(1)

(f) What are the products of electrolysing potassium iodide solution?

Tick **one** box.

Product at cathode	**Product at anode**	
hydrogen	iodine	☐
hydrogen	oxygen	☐
potassium	iodine	☐
potassium	oxygen	☐

(1)

(Total 6 marks)

Mark schemes

1

the atoms are in layers 1

the atoms can slide over each other 1

[2]

2

(a) (i) nucleus 1

(ii) neutron 1

(iii) electron 1

(b) (i) 6 1

(ii) 12 1

(c) $^{14}_{6}C$ 1

(d) (i) CH_4 1

(ii) compound 1

(iii) covalent 1

[9]

3

(a) any **four** from:

*max **3** marks if any reference made to covalent / ionic bonding / molecules or intermolecular forces **or** graphite / diamond **or** forces of attraction between electrons and then ignore throughout*

- giant structure / lattice

  ignore layers

- <u>positive</u> ions

- sea of electrons **or** delocalised / free electrons

  ignore electrons can move

- awareness of <u>outer shell</u> / highest energy level electrons are involved

- (electrostatic) attractions / bonds between electrons and <u>positive</u> ions

- bonds / attractions (between atoms/ ions) are strong

  allow hard to break for strong

  ignore forces unqualified

- a lot of energy / heat is needed to break these bonds / attractions

  ignore high temperature

4

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

accept tiny / really small / a <u>lot</u> smaller / any indication of very small

eg microscopic, smaller than the eye can see

or

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

ignore incorrect numerical values if very small is given

1

(ii) any **2** from:

- one (non-bonded) electron from each atom

- delocalised / free electrons

  allow sea of electrons

  ignore electrons can move

- electron carry / form / pass current / charge

  ignore carry electricity

2

[7]

4

(a) the diameter of the tube is very small

1

(b) (i) three

1

(ii) covalent

1

(iii) bonds

1

[4]

5

(a) kills <u>bacteria</u>

allow destroys bacteria

ignore attacks / reacts with bacteria

ignore 'traps the smell'

or

stops growth of <u>bacteria</u>

ignore microbes

1

(b) small<u>er</u> / <u>very</u> small / tiny

assume they are referring to nanoparticles unless they state otherwise

accept 1 - 100nm in size

accept a few hundred atoms in size

accept normal size particles are (much) larg<u>er</u>

1

(c) any **one** from:

- big(ger) surface area
- react fast(er)

accept more reactive

ignore kill faster

1

(d) so they do not get released during washing
or so they do not get into rivers / ecosystem / environment

1

because this could harm fish / aquatic life
or so the socks keep their odour-preventing properties (owtte)

1

[5]

6 (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]

7 (a) (i) C

1

(ii) C **or** D

1

(iii) A

1

(b) covalent

1

(c) layers

1

can slide / move over each other

accept are weakly bonded (owtte)

allow no bonds between layers

ignore slip / rub

1

[6]

8 (a)

$\frac{6.21}{207}$ $\frac{0.64}{16}$

***1** mark for dividing mass by A_r*
*max **2** if A_r divided by mass*

1

= 0.03 = 0.04

***1** mark for correct proportions*

1

3 4

***1** mark for correct whole number ratio (allow multiples) can be awarded from correct formula*

1

Pb_3O_4

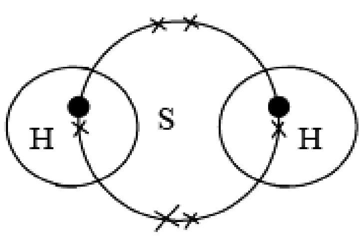
***1** mark for correct formula*

ecf** allowed from **step 2 to step 3** and **step 3 to step 4** if sensible attempt at **step 1

*correct formula with no working gains **2** marks*

1

(b) (i)



*allow all dots **or** all crosses **or** e **or** e^-*

ignore inner shells and any inner electrons

allow 4 non-bonded electrons anywhere on shell as long as not in overlap – need not be paired

1

(ii) forces of attraction / bonds <u>between</u> molecules are weak (owtte)

*do **not** accept intramolecular forces / covalent bonds are weak*

*do **not** accept reference to ions*

or

<u>intermolecular</u> forces / bonds are weak (owtte)

or

it is made of small molecules with weak forces of attraction

*if **2** marks not awarded*

*made of small molecules / simple molecular gains **1** mark*

*forces of attraction are weak (without specifying between molecules / intermolecular) gains **1** mark*

(accept easily broken / not much energy needed to break instead of weak)

bonds are weak without specifying intermolecular would not gain a mark and would be ignored

2

(iii) 4

1

[8]

9

(a) carbon

1

(b) <u>layers</u>

1

have weak forces / attractions / bonds between them **or** are only held together weakly

second mark must be linked to layers

or

can slide over each other **or** separate (1)

1

(c) covalent

1

[4]

10

three from:

*reference to ionic / metallic / intermolecular / (small) molecules = max **2***

structure: (max 2)

- giant structure / macromolecule / all the atoms are joined together

  allow (giant) lattice

  ignore large structure

  ignore diamond structure

- covalent (bonds)
- strong bonds / bonds difficult to break
- each silicon atom forms 4 bond sand / or each oxygen atom forms 2 bonds

explanation: (max 2)

- a lot of energy needed to break the bonds
- high melting point

  *if neither point given accept high temperature needed to break bonds for **1** mark*

- does not burn **or** react with oxygen

3

[3]

11

any **three** from:

any reference to incorrect bonding = max 2

- giant structure / lattice / macromolecule
- covalent (bonds)
- bonds are (very) strong

  allow bonds difficult to break

  ***or** takes a lot of energy to break bonds*

- each atom / carbon joined to four others

  accept each atom / carbon forms four bonds

3

[3]

12

(a) carbon

1

(b) each atom is joined to four other atoms

1

It has a giant structure

1

(c) very small

1

[4]

13

(a) **Graphite:**

because the layers (of carbon atoms) in graphite can move / slide

it = graphite

1

this is because there are only weak intermolecular forces **or** weak forces between layers

accept Van der Waals' forces allow no covalent bonds between layers

1

Diamond:

however, in diamond, each carbon atom is (strongly / covalently) bonded to 4 others

allow diamond has three dimensional / tetrahedral structure

1

so no carbon / atoms able to move / slide

allow so no layers to slide ***or*** *so diamond is rigid*

1

(b) because graphite has delocalised electrons / sea of electrons

allow free / mobile / roaming electrons

1

which can carry charge / current **or** move through the structure

1

however, diamond has no delocalised electrons

accept however, diamond has all (outer) electrons used in bonding

1

[7]

14

(a) (i) covalent

two different answers indicated gains ***0*** *marks*

1

(ii) carbon

*two different answers indicated gains **0** marks*

1

(iii) 3

*two different answers indicated gains **0** marks*

1

(b) layers can slide / slip

1

because there are no bonds between layers

accept because weak forces / bonds between layers

or so (pieces of) graphite rubs / breaks off

or graphite left on the paper

1

[5]

15

(a) 79

1

79

1

(b) hundred

1

(c) (i) electron(s)

1

(ii) three

1

(d) changes rate of reaction

accept lowers activation energy

or

speeds up / slows down reaction

accept reduces costs

1

(e) (i) melt

1

(ii) crosslinking

allow answers on diagram

or

(covalent) bonds between polymers / chains

allow bonds between layers
*do **not** allow intermolecular*

1

[8]

16 (a) 118

1

(b) it loses / transfers electrons

it = Au / gold atom

1

three electrons

*sharing / covalency = max **1** mark*

1

(c) (i) O_2

1

2 CO and **2** CO_2
or
correct balancing of equation from O

accept correct multiples / fractions throughout

1

(ii) *reference to incorrect bonding = **1** mark max*

because carbon dioxide is simple molecular / small molecules

1

there are <u>*intermolecular*</u> forces (between the molecules)

allow <u>intermolecular</u> bonds

1

so a small amount of energy needed (to separate molecules) **or** (*intermolecular forces*) are weak

1

(d) any **three** from:

- gold is the only catalyst for some reactions
- catalysts are not used up
- improves speed of reaction

  reduces amount of energy **or** process needs low(er) temperature

  *if no mark awarded, allow catalyst reduce costs (of the process) for **1** mark*
- only small quantities (of catalyst) needed

3

[11]

17

(a) (i) *ionic / molecules / metallic / (inter)molecular = max **2***

because graphene / it has a giant structure / lattice / macromolecular

accept <u>all</u> / <u>every</u> / <u>each</u> atom is <u>bonded to</u> 3 other atoms

1

because graphene / it has covalent bonds / is covalent

1

because in graphene / the bonds are strong **or**
a lot of energy needed / hard to break the bonds

1

(ii) there are delocalised / free electrons

1

because one (delocalised / free) electron <u>per atom</u> linked to first marking point

accept because three <u>electrons per atom</u> used (in bonding)

accept because one electron <u>per atom</u> not used (in bonding)

1

(b) opaque (owtte)

eg could not see through them

or layers slide
or layers not aligned

ignore thick

1

[6]

18

(a) 1 / one

1

(b) (i) protons

1

(ii) neutrons

1

(iii) 7

1

(c) (i) losing

1

(ii) a positive

1

(iii) electrostatic

1

(d) high melting points

1

strong bonds

1

(e) (i) 58.5

1

(ii) mole

1

(f) very small (particles) **or**

ignore tiny / small / smaller / microscopic etc.

1-100nm in size **or**

(particle with a) few hundred atoms

1

[12]

19 high melting point

*reference to incorrect bonding **or** incorrect particles **or** incorrect structure = max **3***

accept will not melt (at high temperatures)
ignore withstand high temperatures

1

because a lot of energy needed to break bonds

1

because it is covalent **or** has strong bonds

accept bonds are hard to break

1

and because it is a giant structure **or** a macromolecule **or** a lattice

ignore many bonds

1

[4]

20

(a) (alloy) atoms / ions / particles not in layers

accept layers are distorted

accept different (size) particles / atoms

1

so, (alloy) layers / atoms / ions / particles can't slide

*if no other mark awarded allow (an alloy) is a mixture of metals for **1** mark*

1

(b) diamonds have a giant covalent structure

1

diamonds have strong bonds between carbon atoms

1

(c) (i) a compound

1

(ii) CH_4

1

(iii) covalent

1

(d) methane has a low boiling point
or boiling point less than 20°C molecules

1

because it has small molecules

accept it has forces between molecules

*accept weak forces between molecules for **2** marks*

1

[9]

21

(a) carbon

allow C

1

(b) (i) (atoms are in) layers (that) can slide over each other

1

because <u>between</u> the layers there are only weak forces

accept because there are no (covalent) bonds <u>between</u> the layers

accept Van der Waals forces between the layers

*do **not** allow intermolecular bonds between the layers*

*if no other marks are awarded allow weak intermolecular forces for **1** mark*

1

(ii) because each atom forms <u>four</u> (covalent) bonds **or** (diamond is a) giant (covalent) structure **or** lattice **or** macromolecular

*any reference to ionic / metallic bonding or intermolecular forces scores a maximum of **1** mark*

accept carbon forms a tetrahedral shape

1

(and) <u>covalent</u> bonds are strong

accept <u>covalent</u> bonds need a lot of energy / difficult to break

1

(iii) because graphite has delocalised electrons

allow sea of electrons
allow each carbon atom has one free electron

1

which can move <u>through the whole structure</u> (and carry the current / charge / electricity)

1

[7]

22 (a) (i) nucleus

1

(ii) neutron

1

(iii) electron

1

(b) (i) 12

1

(ii) 24

1

(c) any **four** from:

*sharing / covalent / metallic = max **3***

- magnesium (atom) reacts with **two** iodine (atoms)
- magnesium (atom) loses electrons
- **2** electrons (from each atom)
- Iodine (atom) gains electron(s)
- **1** electron or an electron (to each atom)
- iodide ion formed

  allow iodine ion
- iodide has negative charge / is a negative ion / particle

  allow iodine

  ignore I^{2-}
- magnesium ion formed
- magnesium has positive charge
- oppositely charged ions attract
- a giant structure / lattice is formed

  *allow **1** mark for unqualified reference to ion formation or ionic bonding*

4

[9]

23

(a) (i) lead nitrate

accept $Pb(NO_3)_2$

do not accept nitride

ignore (all) nitrate(s)

1

(ii) sodium iodide / potassium iodide

accept NaI / KI

accept other correct soluble iodides eg HI, MgI_2

do not accept sodium iodine / potassium iodine

1

(b) *metallic / sharing / covalent* ***or*** *molecule = max* ***3***

magnesium <u>loses **2** electrons</u>

all three underlined ideas must be present

two underlined ideas = ***1*** *mark eg magnesium loses electrons*
or
magnesium gains 2 electrons
or
magnesium loses 2 ions

nb magnesium ***ion*** *loses 2 electrons =* ***1*** *mark*

2 errors = ***0*** *marks eg magnesium gains electrons*

2

<u>iodine gains **1 / an** electron</u>

all four underlined ideas must be present

three underlined ideas = ***1*** *mark eg iodine gains electron(s)*
or
iodine loses 1 / an electron
or
iodide gains 1 / an ion
or
iodide (ion) gains 1 / an electron

2 errors = ***0*** *marks*

2

(c) attractions / forces (of attraction) / bonds are <u>strong</u> **or** lot of energy needed to break bonds / forces / attractions

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

1

because oppositely charged ions <u>attract</u> **or** electrostatic <u>attraction</u> between ions

1

in giant structure **or** lattice

ignore many bonds

ignore ionic bonding unqualified

1

[9]

24 (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]

25 (a) <u>layers</u>

which have weak forces / attractions / bonds between them

second mark must be linked to layers

1

or

which can slide over each other **or** separate

ignore references to rubbing

1

(b) covalent

1

[3]

26 (a) a layer a few hundred atoms thick

1

(b) any **two** from:

*any **two** ideas*

- less materials or save resources
- less energy
- less fuel
- less pollution / greenhouse effect / global warming
- less waste

ignore references to cost / recycling

2

[3]

27 (a) (Chromium =) 20

in correct order

1

(Nickel =) 8

*accept Chromium = 8 **and** Nickel = 20 for **1** mark*

1

(b) (i) (because iron is made up of only) one type of <u>atom</u>

1

(ii) not strong

*allow too soft **or** too flexible*

*accept it rusts / corrodes **or** that it could wear away*

accept could change shape / bend

accept layers / atoms could slide (over each other)

1

(iii) structure is different / distorted / disrupted

*accept not in layers **or** not regular*

1

so it is difficult for layers / atoms / particles to slip / slide (over each other)

accept layers cannot slip / slide

1

[6]

28

(a) (i) any **two** from:

ignore any conclusion drawn referring to data below 7.5 nm or above 20 nm

- *100% of (type 1 and type 2) bacteria are killed with a particle size of 7.5 to 8.5 nm*

  accept nanoparticles in the range of 7.5 to 8.5 nm are most effective at killing (type 1 and type 2) bacteria
- *as the size increases (beyond 8.5 nm), nanoparticles are less effective at killing (type 1 and type 2) bacteria*
- *type 1 shows a linear relationship* ***or*** *type 2 is non-linear*
- type 1 bacteria more susceptible than type 2 (at all sizes of nanoparticles shown on the graph)

  allow type 2 bacteria are harder to kill

2

(ii) (yes) because you *could confirm the pattern that has been observed*

allow would reduce the effect of anomalous points / random errors

allow would give better line of best fit

ignore references to reliability / precision / accuracy / reproducibility / repeatability / validity

or

(no) because trend / *conclusion* is already clear

1

(b) magnesium loses electron(s)

1

oxygen gains electron(s)

1

<u>two</u> electrons (per atom)

1

gives full outer shells (of electrons) **or** *eight electrons in highest energy level*

reference to incorrect particles ***or*** *incorrect bonding* ***or*** *incorrect structure = max* ***3***

1

or

(electrostatic) attraction between ions **or** forms ionic bonds

accept noble gas structure

[7]

29

(a) four

1

covalent

1

(b) because it has a high melting point

accept it won't melt

accept it won't decompose or react

allow withstand high temperatures

ignore boiling point

1

(c) thin

1

[4]

30

(a) *weaker bonds*

allow (other substances) react with the silicon dioxide

or

fewer bonds

ignore weaker / fewer forces

or

disruption to lattice

*do **not** accept reference to intermolecular forces / bonds*

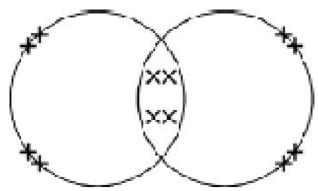
1

(b) (i) Na_2O

*do **not** accept brackets or charges in the formula*

1

(ii)



electrons can be shown as dots, crosses, e or any combination

2 bonding pairs

accept 4 electrons within the overlap

1

2 lone pairs on each oxygen

accept 4 non-bonding electrons on each oxygen

1

(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]

31

(a) nanotubes can slide (over each other)

allow nanotubes can roll (over each other)

1

because no (covalent) bonds between the nanotubes

accept weak forces between the nanotubes ***or*** *weak intermolecular forces*

allow layers for nanotubes throughout

1

(b) delocalised electrons

accept free electrons

1

so (delocalised) electrons can move <u>through the graphite</u>

accept so (delocalised) electrons can carry charge <u>through the graphite</u>

1

[4]

32 Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response.

0 marks
No relevant content

Level 1 (1–2 marks)
*There is a statement about the bonding and / or structure **or** melting / boiling point of chlorine **or** sodium chloride.*

Level 2 (3–4 marks)
*There are statements about the bonding and / or structure of chlorine **or** sodium chloride.*

Level 3 (5–6 marks)
*There are statements about the bonding and / or structure of chlorine **and** sodium chloride.*

*There is an explanation of why chlorine is a gas **or** sodium chloride is a solid.*

Examples of chemistry points made in response:

Chlorine:

covalent bonds between atoms

forming (simple) molecules

no / weak attraction / bonds between molecules

low boiling point

Sodium chloride:

*ionic bonds **or** electrostatic attraction*

strong bonds

in all directions

between oppositely charged ions

forming giant lattice

large amounts of energy needed to break bonds

high melting point

[6]

33 (a) (i) high 1

(ii) hundred 1

(b) hard 1

(c) (i) carbon 1

(ii) four 1

(iii) covalent 1

(iv) all 1

[7]

34 (a) (i) Proton 1

(ii) Neutron 1

(b) In order of increasing atomic number 1

(c) (i) 9 1

(ii) Gas 1

(d) (i) gains (one) electron 1

(to gain a) full outer energy level **or** noble gas configuration

allow because it has seven outer electrons

1

(ii) add sodium hydroxide (solution)

allow ammonia (solution) ***or*** *ammonium hydroxide* ***or*** *any other soluble hydroxide* ***or*** *flame test*

1

(forms a) blue precipitate

second mark dependent on suitable reagent being added

allow blue−green / blue / green if flame test given

1

[9]

35 (a) (i) two 1

(ii) a molecule

1

(iii) one pair of electrons between nitrogen and each of 3 hydrogens

1

rest correct

second mark dependent on first

1

(b) (i) (g) (s)

1

(ii) chloride

ignore formulae

1

(c) (i) any **one** from:

- wear goggles
- wear gloves
- do not breathe in fumes
- wipe up spills immediately
- work in a fume cupboard

1

(ii) (particles of) ammonia move faster than (particles of) hydrogen chloride

allow diffuses faster

allow hydrochloric acid

1

(iii) particles / molecules have more energy

*do **not** accept atoms / ions*

1

so they move faster

ignore references to rate of reaction

1

[10]

36 (a) lattice / giant structure

*max **3** if incorrect structure or bonding or particles*

1

ionic **or** (contains) ions

1

Na^+ **and** Cl^-

accept in words or dot and cross diagram: must include type and magnitude of charge for each ion

1

electrostatic attraction

allow attraction between opposite charges

1

(b) hydrogen

allow H_2

1

sodium hydroxide

allow NaOH

1

(c) any **one** from, eg:

- people should have the right to choose
- insufficient evidence of effect on individuals
- individuals may need different amounts.

allow too much could be harmful

ignore religious reasons

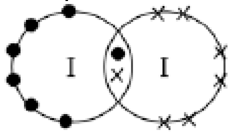
ignore cost

ignore reference to allergies

1

(d) (i) one bonding pair of electrons

accept dot, cross or e or − or any combination, eg



1

6 unbonded electrons on each atom

1

(ii) simple molecules

*max **2** if incorrect structure or bonding or particles*

accept small molecules

accept simple / small molecular structure

1

with intermolecular forces

accept forces between molecules

must be no contradictory particles

1

which are weak **or** which require little energy to overcome − must be linked to second marking point

reference to weak covalent bonds negates second and third marking points

1

(iii) iodine has no delocalised / free / mobile electrons or ions

1

so cannot carry charge

*if no mark awarded iodine molecules have no charge gains **1** mark*

1

[14]

37 (a) (i) giant lattice

allow each carbon atom is joined to three others

1

atoms in graphene are covalently bonded

*max. **2** marks if any reference to wrong type of bonding*

1

and covalent bonds are strong **or** need a lot of energy to be broken

allow difficult to break

1

(ii) because graphene has delocalised electrons

allow each carbon atom has one free electron

1

which can move <u>throughout the structure</u>

*do **not** accept just electrons can move.*

1

(b) because there are weak forces between molecules

allow no <u>bonds</u> between the layers

1

so layers / molecules can slip / slide.

1

[7]

38 (a) magnesium <u>loses electrons</u>

there are four ideas here that need to be linked in two pairs.

1

<u>two electrons</u>

1

<u>chlorine gains electrons</u>

*magnesium <u>loses</u> electrons and chlorine <u>gains</u> electrons scores **2** marks.*

1

<u>two atoms of chlorine</u>

magnesium <u>loses</u> <u>two</u> electrons and <u>two chlorines</u> each <u>gain</u> one electron will score full marks.

1

(b) 95

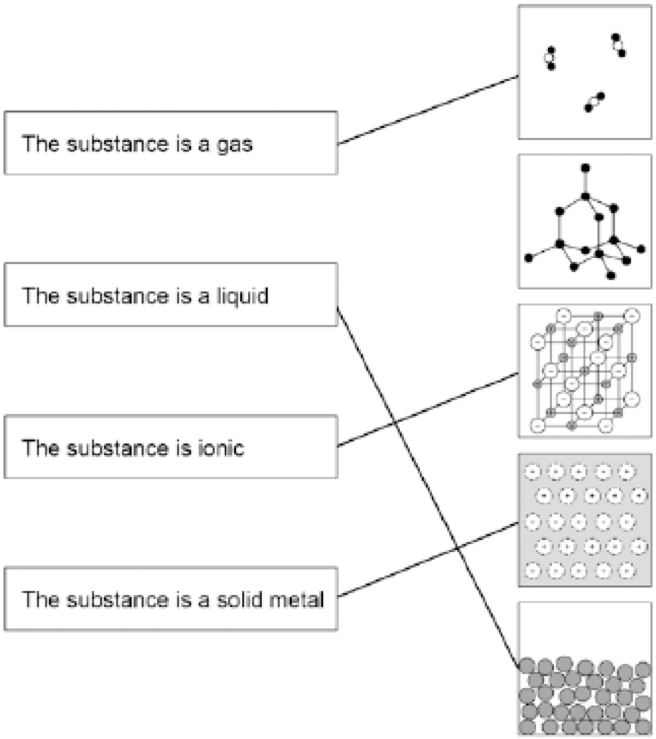
*correct answer with or without working gains **2** marks*

*if answer incorrect, allow 24 + 35.5 + 35.5 for **1** mark*

2

[6]

39 (a) **Statement** **Structure**



more than one line drawn from a variable negates the mark

4

(b) Carbon

1

(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]

40

(a) giant structure / lattice / layers / close packed

first 3 marks can be obtained from a suitably labelled diagram

incorrect structure or bonding or particle = max 3

1

made up of atoms / <u>positive</u> ions

1

with delocalized / free electrons

1

so electrons can move / flow through the metal

accept so electrons can carry charge through the metal

accept so electrons can form a current

1

(b) an alloy (is a metal which) has different types / sizes of atoms

accept converse for pure metal throughout

both marks can be obtained from suitable diagrams

allow made of different metals

allow mixture of metals / atoms / elements

ignore particles

ignore properties

*do **not** accept compound*

1

alloy has distorted layers

allow layers are unable to slide

1

(c) (i) can return to its original shape

accept shape memory alloy

accept smart alloy

ignore other properties

1

(ii) (pure copper is too) soft

accept converse

accept malleable or bends

accept copper is running out

ignore references to strength and weakness

1

(iii) aluminium oxide

accept alumina

accept Al_2O_3

ignore bauxite / aluminium ore

1

(iv) any **one** from:

- different conditions
- different catalyst
- different pressure

  allow different concentration
- different temperature.

  *do **not** accept different monomers*

1

(d) any **two** from:

- accurate
- sensitive
- rapid
- small sample.

both needed for 1 mark

1

[11]

41 (a) (i) neutrons

this order only

1

electrons

1

protons

1

(ii) box on the left ticked

1

(b) (i) effervescence / bubbling / fizzing / bubbles of gas

do ***not*** *accept just gas alone*

1

magnesium gets smaller / disappears

allow magnesium dissolves

allow gets hotter ***or*** *steam produced*

ignore references to magnesium moving and floating / sinking and incorrectly named gases.

1

(ii) Marks awarded for this answer will be determined by the Quality of Communication (QC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking Guidance and apply a 'best–fit' approach to the marking.

0 marks
No relevant content

Level 1 (1−2 marks)
There are simple statements of some of the steps in a procedure for obtaining magnesium chloride.

Level 2 (3−4 marks)
There is a description of a laboratory procedure for obtaining magnesium chloride from dilute hydrochloric acid and magnesium.

The answer must include a way of ensuring the hydrochloric acid is fully reacted **or** a method of obtaining magnesium chloride crystals.

Level 3 (5−6 marks)
There is a well organised description of a laboratory procedure for obtaining magnesium chloride that can be followed by another person.

The answer must include a way of ensuring the hydrochloric acid is fully reacted **and** a method of obtaining magnesium chloride crystals.

examples of the points made in the response:

- hydrochloric acid in beaker (or similar)
- add small pieces of magnesium ribbon
- until magnesium is in excess or until no more effervescence occurs *
- filter using filter paper and funnel
- filter excess magnesium
- pour solution into evaporating basin / dish
- heat using Bunsen burner
- leave to crystallise / leave for water to evaporate / boil off water
- decant solution
- pat dry (using filter paper).

*Student may choose to use a named indicator until it turns a neutral colour, record the number of pieces of magnesium added then repeat without the indicator.

6

[12]

42 (a) (i) C

1

(ii) B

1

(iii) A

1

(iv) D

1

(b) (i) SO_2

1

(ii) shared

1

(iii) covalent

1

[7]

43 (a) electrons transferred from potassium to sulfur

1

two potassium atoms each lose one electron

1

forming K^+ / 1+ ions

1

sulfur atoms gain 2 electrons

1

forming S^{2-} / 2− ions

1

(b) there are no gaps / sticks between the potassium ions and sulfide ions

1

(c) (two) shared pairs between H and S

1

rest correct - no additional hydrogen electrons and two non-bonding pairs on sulfur

second mark dependent on first

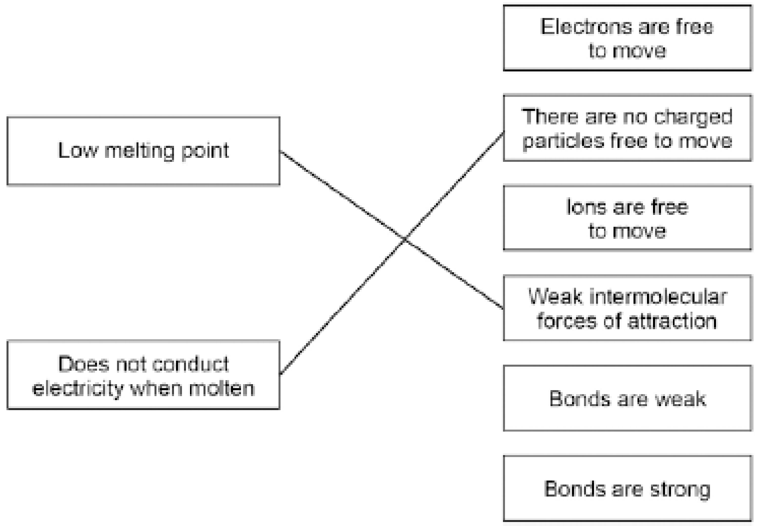
1

(d) 342

2

*allow **1** mark for evidence of (2 × 27) + 3[32 + (16 × 4)]*

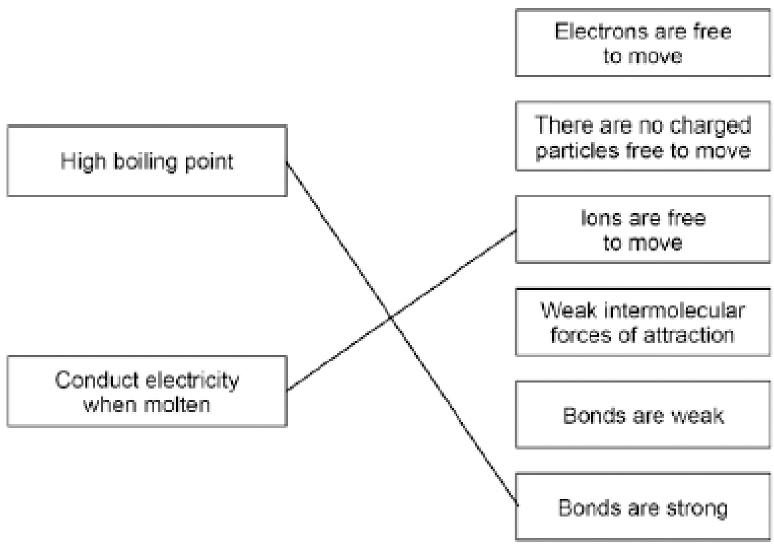
(e) **Property** **Explanation of property**



more than one line drawn from a variable negates the mark

2

(f) **Property** **Explanation of property**



more than one line drawn from a variable negates the mark

2

[14]

44 (a) has delocalised electrons

accept free (moving) electrons

1

(so electrons) can move through the structure/metal

accept (so electrons) can carry charge through the structure/metal

accept (so electrons) can form a current

1

*reference to incorrect particles **or** incorrect bonding **or** incorrect structure = **max 1***

(b) giant structure

accept lattice

accept each atom forms four bonds (with other carbon atoms)

ignore macromolecular

1

strong bonds

accept covalent

*do **not** accept ionic*

1

*reference to intermolecular forces/bonds **or** incorrect particles = **max 1***

(c) thermosetting polymers do not melt (when heated)

accept thermosetting polymers do not change shape (when heated)

accept thermosetting polymers have high(er) melting points

ignore thermosetting polymers do not soften (when heated)

1

due to cross-links (between chains)

accept due to bonds between chains

1

*reference to smart polymers = **max 1***

accept converse argument

[6]

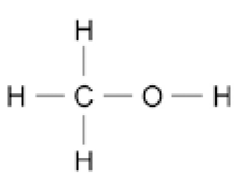
45 (a) Propanol

1

(b) Butanol has the highest boiling point

1

(c)



1

(d) ethene + water (→ ethanol)

allow answers in either order

allow steam for water

1

(e) goes back to reactor

allow is recycled

1

(f) air contains oxygen

1

which oxidises ethanol

allow ethanol reacted with oxygen

1

to produce ethanoic acid

1

[8]

46 (a) The forces between iodine molecules are stronger

1

(b) anything in range +30 to +120

1

(c) Brown

1

(d) $2\ I^- + Cl_2 \rightarrow I_2 + 2\ Cl^-$

1

(e) It contains ions which can move

1

(f) hydrogen iodine

1

[6]

Examiner reports

1

The question gave a friendly start to the paper. Almost all of the candidates gained at least one of the two marks. A few candidates ticked only one statement.

2

(a) (i) Nucleus and neutron were well known in this part and (a)(ii)

(iii) In this part fewer of the candidates realised that electrons have a negative charge.

(b) (i) The concepts of atomic number and mass number were well understood by most of the candidates in parts this part and (b)(ii) although slightly more of the candidates understood atomic number.

(c) This part was less well known with a large number of candidates opting for $^{8}_{6}C$.

(d) (i) A large number of students gave, CH_4 , rather than the correct answer CH_4

(ii) Most candidates answered this part of the question and part (d)(iii) correctly although a sizeable number gave the alternative responses.

3

(a) The majority of the candidates gained one or two marks but few went on to gain the third or fourth mark. Some candidates gave very confused answers which mixed different types of bonding in their descriptions. Where candidates gave incorrect chemistry using terms such as molecules, ionic bonding, intermolecular forces etc their mark was limited to a maximum of three out of four. Many of the candidates seem to find metallic bonding more difficult than the other types of chemical bonding. The mark scheme had a list of seven points from which the candidate needed to give any four in order to gain full marks. A simple four mark answer might have been: Metals have positive ions (*1 mark*) in a sea of delocalised electrons (*1 mark*). The positive ions are strongly bonded (*1 mark*) and a lot of energy is needed to break the bonds (*1 mark*).

(b) (i) Most of the candidates understood the meaning of the term nano. Some candidates incorrectly thought that the atoms are smaller in the carbon nanotubes.

(ii) A good number of the candidates gained one mark but fewer went on to gain two. The most commonly gained mark was for stating that there are delocalised electrons. The second mark could be gained either by stating that one delocalised electron comes from each carbon atom or for indicating that the delocalised electrons carry the electric current. Some candidates gave confused answers based on the layered structure of graphite.

4

(a) This was very well answered.

(b) Generally well answered although a significant number of candidates opted for two bonds in part (b)(i) and ionic bonding in part (b)(ii)

5

(a) Most of the candidates were able to recognise that bacteria were killed by the action of silver here; some answers lacked detail and waffled about the silver trapping smells.

(b) The majority of candidates were aware of the need to write smaller rather than just small as a comparison.

(c) This question was a good discriminator and was less well answered. The idea that nanoparticles have a larger surface area was not well understood and there were very few correct answers. Most of the answers referred to the small size of the particles and as a result more could be packed into a small area or fit into the particles more easily. Other responses discussed the trapping of bacteria and smells and preventing them escaping.

(d) This question was well answered and most candidates scored full credit. Most candidates linked the ideas of not being washed out into rivers, therefore not harming the fish. A number of candidates wrote 'if silver is released... ..' and only implied that it would be better not to release the silver and did not give sufficient detail.

6

(a) (i) Most students gained at least one of the two marking points awarded for a description of the structure of gold. Only the strongest students gained the third marking point for a description of metallic bonding in terms of attraction between positive ions and electrons. A small number of students used the data sheet to give the structure of a gold atom in terms of numbers of protons, neutrons and electrons. This did not gain credit.

(ii) This question was well answered although some students gave answers such as "because it's an unreactive metal" or "because its atoms are tightly packed together" without conveying the idea that electrons can move through the structure or simply stating that gold contains "delocalised electrons".

(b) Students found this to be a challenging question. Some answers lacked sufficient depth; a common response was the idea of a surface layer acting as a barrier. Other students went no further than stating that the corrosion of metals is an oxidation process. Only a few students gained two marks for considering the formation of an ionic compound in which the ions are not free to move. A significant minority of students gained a mark for the idea that there are no delocalised electrons in the corroded surface layer (or fewer delocalised electrons in the metal as a whole).

7

(a) Most students scored at least one mark.

(b) Covalent was the common correct choice.

(c) A large number of students realised that the particles were arranged in layers that could slide or move over each other or that the layers were joined by weak bonds. Vague references to 'the layers having weak bonds' only scored partial credit. Vague answers referring to weak bonds in the layers, atoms being not close together and particles rubbing or slipping received no credit.

8

(a) Empirical formulae calculations can be very challenging, but it was pleasing to see that a majority of candidates gained 2 or more marks, and most were able to make a realistic start to the calculation. Having successfully started the calculation by dividing the mass by the A_r for each element, a significant number of candidates found obtaining a whole number ratio challenging, and so rounded the ratio of 1:1.3 to give 1:1, and hence PbO as the formula, gaining credit for the correct working, though not for the incorrect answer. Even lower scoring candidates were aware that division was needed to start the calculation, but some were unsure about what to divide. Other common errors included Pb_4O_3 (obtained by confusing and swapping the elements part way through the calculation, or by dividing the A_r by the mass for each element), and Pb_3O_2 (obtained by dividing 0.64/32 for oxygen). It was pleasing to see that many answers were clearly written with logically presented working, enabling examiners to award the credit due. A small minority of candidates continue to give a jumble of numbers, or no working at all. If no correct working was given or discernable, then 2 marks were awarded if a correct answer is given. Correct working had to be shown to access the remaining marks.

(b) (i) The majority of candidates gained credit in this question. The most common errors included putting more electrons in the outer shell of sulfur than 2 lone pairs, adding an extra electron to the hydrogen shell, or giving only 2 lone electrons on the sulfur shell. A minority of candidates put 3 bonding electrons in the overlap between the hydrogen and sulfur shells. If crossings out are necessary, candidates should be encouraged to make the diagram clear.

(ii) This question revealed a number of misconceptions, and discriminated well. Candidates showed some confusion between covalent bonds and intermolecular forces, with many stating that covalent bonds are weak. There were some excellent responses, but others showed that candidates had learnt the phrase 'weak intermolecular forces', while the rest of their answer revealed that they did not understand it, for example stating that covalent bonds have weak intermolecular forces. Examiners found occasional references to ionic bonds or delocalised electrons. There were many references to unspecified weak bonds.

(iii) The majority of candidates gained this mark with 2 often seen as an incorrect response.

9

(a) This part was generally well answered although some of the candidates named lead as the element.

(b) Here some failed to gain credit because they discussed the idea of weak bonds and atoms rubbing off, often in great detail and sometimes referring to friction, but made no reference to the layers in the graphite which were weakly held together or could slide over each other. Others gave answers in terms of layers which were strongly bonded.

(c) Less than half of the candidates correctly identified that covalent bonds held the carbon atoms together in the layers in (c)

10

There were some excellent and detailed answers to this question. Many of the answers showed a sound knowledge of the structure and bonding in silicon dioxide and the ability to apply this knowledge to the welding situation. A number of candidates sought to explain more than one suitable property and continued on to discuss electrical, thermal conductivity or strength. Common errors included assuming the structure contained carbon atoms, and incorrect numbers of bonds (often 3 to silicon). A number of candidates lost a mark because they made reference in their answers to an incorrect type of bonding such as intermolecular forces or ionic bonding.

11

The hardness of diamond was generally well explained in terms of its structure and bonding, with some excellent, comprehensive answers seen.
Some students made references to incorrect types of bonding, especially “intermolecular”.
“Each carbon is joined to three others” was also stated by a significant minority of students. This type of error limited their mark to a maximum of two.

12

Students knew that diamond was a form of carbon and were able to link the properties of diamond to explain the hardness of diamond. The relative size of nanoparticles was also well known.

13 (a) This question proved to be a good discriminator. The marking point relating to the intermolecular forces in graphite was gained by only the most able students, but that relating to layers sliding in graphite proved the most accessible. A small minority of students referred to incorrect bonding (eg intermolecular forces in diamond) or structure (simple molecular) in their answers. A small minority of the students also referred to crosslinking and thermosetting. Some students mistook softness for flexibility, referring to graphite being able to bend. Some students were content to explain why graphite was soft but then failed to go on to address why diamond was not soft, therefore not gaining the marks for that part of the mark scheme.

(b) Conductivity in graphite and diamond was well understood by many candidatesstudents, although some failed to refer to the delocalised electrons as charge or current carriers or as moving throughout the structure so did not gain the second marking point. A small minority of students were unable to relate conductivity to electron structure at all, and some referred to the need for graphite to be molten to conduct electricity.

14 (a) Most students scored full marks for these three parts.

(b) Generally well answered with a large number of students fully understanding the idea of layers in graphite that could slide or move over each other. Only a minority were able to explain that the layers were joined by weak bonds. Vague references to the layers having weak bonds, weak bonds in the layers, atoms not being close together and particles rubbing or slipping received no credit.

15 (a) A minority of students scored full credit. Many students did not appear to know these basic chemistry principles. 197 and 79, sometimes reversed, were the most common answers.

(b) & (c) Wild guesses were evident.

(d) The function of a catalyst is well known by many students.

(e) Responses showed that students did not understand the structure of a thermosetting polymer. Vague answers were prevalent referring to chains overlapping, strong bonds between the atoms and intermolecular forces and atoms in chains. Reference to cross links was rare.

16

(a) While a large majority of students gained credit, the most common error was 79. Other errors included 197, 79 and 39.

(b) Many students demonstrated a sound understanding of the process of ionisation. Students gaining only 1 of the 2 marks referred either to the gaining of 3 electrons, or omitted the number of electrons lost. A small minority of students referred to the wrong particle, thus gaining no credit.

(c) (i) It was heartening to see that approximately half of students successfully balanced the equation. Those gaining 1 mark often used O rather than O_2. A small minority of students introduced species other than oxygen on the left hand side, often gold, thus failing to gain credit, as they did not balance the equation.

(ii) Many students wrote with understanding about the weak intermolecular forces in carbon dioxide. Students gaining 2 rather than 3 marks often did not explain that carbon dioxide comprises small molecules or has a simple molecular structure. A small minority of students either failed to mention intermolecular forces, or placed them in an incorrect context. A relatively small proportion of students referred to "weak bonds".

(d) A high proportion of students recalled at least one characteristic of catalysts, but a much smaller proportion could apply three ideas to the context of gold as a catalyst. Many students realised that use of gold as a catalyst reduces energy costs or speeds up the reaction, thus defraying the cost of the gold. Students also recalled that catalysts can be reused, but fewer students noted that only small quantities are needed or the specificity of catalysts. Some students referred to the low reactivity of gold as an advantage suggesting that it would not react. The weakest students recounted general properties of metals.

17

(a) (i) This proved to be a very discriminating question. Of the students who gained less than three marks, many mentioned other types of bonding, including ionic bonding and intermolecular forces. Some students even included all 3 types of bonding for good measure – no doubt hoping that one would be right and pick up some marks! In this and 4ai, some students wrote about bonds being joined together strongly – muddling bonds with particles being bonded together, eg "bonds are held together by strong forces of attraction." Many students gained credit for "giant covalent structure", but then went on to mention intermolecular forces.

(ii) The majority of students recognised that the presence of delocalised or free electrons enables graphene to conduct electricity. However, only the most complete responses (a minority) clearly explained that each atom provided one delocalised electron. As in (a)(i), examiners had difficulty interpreting some students' answers due to imprecise language eg rather than each atom having one electron not used in bonding, some students wrote that each molecule has one spare atom,"only 3 bonds are connected, so one bond is free to move around", free atoms. Some students only scoring one mark said that there was one free electron, but omitted to say per atom. In high demand questions, students are expected to be able to express their understanding of chemical concepts clearly, and in such a way that examiners can readily interpret their answers, even on quite complex topics such as why graphene is strong or conducts electricity. Where answers are difficult to interpret, or are ambiguous due to imprecise use of language, credit cannot be awarded.

(b) A majority of students realised that a screen with a large number of carbon layers would not be transparent. A significant number of students also gained credit for recognising that with multiple layers, the layers could slide. However of those who gained no credit, many stated that the screen would be too thick, without specifying a problem which would arise from this. Others felt that the multiple layered screen would not be strong enough, or be too thick and rigid to respond to touch.

18

(a) These question was generally well answered. The group number for lithium and sodium was usually correctly given as 1.

(b) Generally well answered question. A common incorrect answer for the mass number of lithium was 3.

(c) (i)(ii) The majority of students successfully interpreted the diagram to correctly answer parts (i) and (ii). Some wild guesses were evident.

(iii) The identification of the correct forces in this part posed most problems. A significant number of students chose one of the wrong options.

(d) This question differentiated well. Only the more able students scored full credit.

(e) (i) Common incorrect answers were obtained by subtracting the relative atomic masses to give 12.5 or by their product to give 816.

(f) The idea of the magnitude of nanoparticles being 'very small' was well understood. However, a significant number of students still refer to them as being microscopic, tiny or small, or make a comparison with normal particles by describing them as being smaller. There were also irrelevant references to the taste and flavour imparted by the particles.

19

Only the most able students gained full credit. While many students recognised that the silicon dioxide would have a high melting point, few related this to the large amount of energy needed to break the bonds. Many students recognised the structure to be giant or macromolecular or a lattice, but some went on to refer to carbon atoms or discuss layers sliding. Many students, especially those who referred to the structure as "giant molecular" were unsure of the type of bonding present, often referring incorrectly to intermolecular forces in their response. Intermolecular forces were even referred to as "intermolecular forces between bonds".

Students are advised to focus their answers on the question rather than just writing down all they can remember about the material.

20

(a) Many students scored credit for reference to atoms of different sizes being present in the alloy or the idea that the rows/layers were distorted. A minority of students realised that this meant that they could not slide/slip over each other. Lots of vague statements referred to gaps in the structure, strong bonds and splitting of atoms.

(b) Generally well answered though some students only ticked one box instead of two as requested.

(c) (i) It was evident that guesses were common.

(ii) It was evident that guesses were common.

(iii) Ionic and metallic were common incorrect answers.

(d) This question showed a lack of knowledge and understanding with few students realising that methane has small molecules. A lot of students hedged their bets stating that weak (covalent) bonds were present between carbon and hydrogen atoms rather than weak forces between molecules. One mark was often obtained for recognising that methane has a low boiling point but there was much confusion with melting point. Some students stated that methane has a high boiling point or that its boiling point was 20°C. Vague references to crude oil and methane being formed showed a lack of knowledge and understanding.

21

(a) Students found this question easy and most knew that both diamond and graphite were both forms of carbon.

(b) (i) Many students found this part difficult. A lot of students wrote about atoms sliding rather than layers sliding. Many students did not state that there were weak forces between the layers or no bonds between the layers.

(ii) Most students showed a good knowledge of diamond. Many students failed to score the second mark because they made reference to bonding other than covalent or referred to intermolecular forces.

(iii) This question discriminated well. Most students recognised that graphite has delocalised electrons and most scored 1 mark. Many students stated simply that delocalised electrons can move. To score full marks the student had to state or imply that to conduct electricity delocalised electrons need to move throughout the structure.

22

(a) The structure of the magnesium atom was well known by most students.

(b) Most students were able to correctly identify the mass and atomic number of magnesium.

(c) This question discriminated very well with a good range of marks being obtained by the students. Some excellent answers were seen with students being able to interpret the diagram and use their knowledge of ionic bonding to explain the processes taking place. Some students were able to explain how the ions were formed in both magnesium and iodine to produce magnesium iodide but then lost a mark by describing the bonding as covalent or suggesting that the atoms are sharing electrons. However a number of students gave very confused answers in which the key words (ion, atom and electron) were used, but with a lack of understanding of their use in the process or were related to the wrong context. Some students discussed the transfer of protons or atoms rather than electrons.

23

(a) (i) Only about a quarter of students gained credit in these question parts. Of the incorrect responses, a reasonable proportion of students gave responses such as “all nitrates”, or “most chlorides, bromides and iodides” from the table or just “chloride”, suggesting a poor understanding of the nature of a compound.

(ii) Only about a quarter of students gained credit in these question parts. Of the incorrect responses, a reasonable proportion of students gave responses such as “all nitrates”, or “most chlorides, bromides and iodides” from the table or just “chloride”, suggesting a poor understanding of the nature of a compound.

(b) This question differentiated well, and most students were able to make an attempt at describing ionic bonding. The most able students gained marks very succinctly, but those with a weak understanding of ionic bonding were not able to make a realistic attempt, and at best just wrote incorrectly about the atoms sharing electrons. The most common error was to suggest that a single iodine atom would gain two electrons. A number of students also incorrectly referred to iodine ions.

(c) Only the most able students gained full marks, demonstrating a secure understanding of the reasons for high melting points in ionic compounds. Although the most commonly gained mark was that for strong bonds, there were many misconceptions, and students often gave an incorrect type of bond. Many students omitted to mention the giant structure or lattice, while others referred to the compound as potassium iodine.

24

(a) The bonding in metals was not well understood. About two thirds of students gained only one mark in this question, and about half of those gained a further mark. Few gained full credit. A number of students wrote about the layers in metals, relating these to flexibility, and many wrote about delocalised electrons, explaining that good conductivity of heat caused the high melting point.

Some students appeared to write down all they knew about metals, in the hope that some of it was relevant, and there were many references to incorrect bonding for example intermolecular or covalent bonding.

(b) (i) There were many correct responses. The few students who did not gain credit generally only indicated that the carbon nanotubes were small, rather than very small.

(ii) Students generally recognised that delocalised or free electrons are responsible for electrical conductivity in carbon nanotubes, with about half of the students gaining one of the two available marks. Some responses were not sufficiently clearly expressed to gain credit (for example "delocalised bonds"). Some students thought that the current could flow between the atoms because they were all joined together.

25

(a) Most students were able to identify that graphite contained layers which enabled graphite to rub off on the pencil. However their responses did not expand on the information given in the diagram and few made reference to the weak bonds between the layers or the layers being able to slide over each other. Others gave answers in terms of layers which were strongly bonded.

(b) Over half the students correctly identified that covalent bonds held the atoms together in each of the graphite layers.

26

(a) Few students chose the correct description of a 'nanosize' layer with most choosing 'a layer millions of atoms thick'.

(b) Many students just repeated information given in the question rather than using this to suggest ideas as to why nanocoated tennis balls would be good for the environment. Correct responses usually related to the use of less materials or less waste rather than less energy use in the manufacture. Some students did not include comparators in their responses. Others thought that the loss of air from normal tennis balls would increase the level of pollution.

27

(a) The majority of students correctly calculated the percentages of chromium and nickel in stainless steel.

(b) (i) Surprisingly a large number of students could not define an element.

(ii) A large majority of students knew that the softness of pure metal made it unsuitable for a replacement hip joint.

(iii) Surprisingly most students could not explain, in terms of structure, why stainless steel is harder than pure iron.

28

(a) (i) Despite some confusion between nanoparticles and bacteria, a large majority of students gained at least one mark. Some students referred to type 1 and type 2 nanoparticles, others misread the graph, suggesting 5.5 nm – 5.6 nm as the optimum size, or that bacteria were more effectively killed by larger nanoparticles. Other students interpreted the graph as showing the rate at which bacteria were killed.

(ii) A substantial minority of students gained credit. There were many vague references to improving accuracy or precision.

(b) This question discriminated well, and gave many students the opportunity to demonstrate their knowledge. Occasionally students suggested an incorrect particle being transferred, or electrons being transferred in the wrong direction. A number of students had difficulty using the correct nomenclature, for example suggesting that ions lost or gained electrons.

29 (a) Guesses were evident here, with just under half of students gaining one mark, and only a quarter of students gaining both marks.

(b) Many students scored credit by reference to the high melting point of the silicon dioxide or stating that it would withstand high temperatures. Vague answers involved detail about the bonding or the insulating effect of the silicon dioxide.

(c) Generally well answered.

30 (a) A minority of students gained this mark. Many students implied that silicon dioxide has intermolecular forces.

(b) (i) Students' ability to write formulae is improving, although only a third achieved credit. Common incorrect answers included NaO and NaO_2.

(ii) A majority of students gained at least one mark. Common errors included adding 1 bonding pair with 3 lone pairs of electrons on each oxygen (a chlorine structure), and 2 bonding pairs with 3 lone pairs of electrons on each oxygen.

(c) A substantial minority of students gained all 3 marks. Some students omitted to mention delocalised or free electrons, so gaining only 2 marks. Weaker students gave vague descriptions or lists of properties of metals, for example dense, shiny or strongly bonded. A minority of students also correctly described the lattice and delocalised electrons but failed to mention the type of particle in the lattice. Some students referred to the metals, rather than their constituent ions, as positively charged. Others were limited to two marks by the inclusion of intermolecular forces in their answer.

31 (a) About half of the students gained credit, with many realising that the nanotubes would slide over each other. However, few were able to suggest why this happens. Some students referred to the size of the nanotubes, or their surface area.

(b) A majority of students recognised the involvement of delocalised electrons, but fewer were able to explain why they enable graphite to conduct electricity.

32 This question discriminated well. Weaker students simply described the diagram and many did not read the question. Whilst describing the bonding in chlorine it was difficult at times to work out whether students were referring to the covalent bonds or intermolecular forces and there was also confusion over the relative strength of these bonds. Many thought that covalent bonds are broken when chlorine boils. There was a lot of mixing up of the terms ionic and covalent. Good answers specified the strong ionic bonds in the sodium chloride giant lattice structure and the weak forces between the covalently bonded chlorine molecules. Only a minority were able to discuss the energy needed to break the bonds in the different structures and get full credit.

A lot of students described the bonding in the metal sodium and then went on to describe in detail how the chlorine and sodium bonded through electron transfer. Many gave electron arrangements and explained why they reacted but unfortunately these irrelevant descriptions could gain no credit.

Some students were able to recognise the link between melting points and boiling points and physical state. Unfortunately only the more able students were able to link the strength of bonding to physical state.

33 (a)(i), (b) and (c)(i), (iii), (iv) were generally well answered. A common incorrect answer for (a)(ii) was million. In (c)(ii) about half were correct.

34 The majority of candidates scored full marks in the multiple choice questions.

(c) (ii) Least well answered of the multiple choice questions. A number of candidates presumably read the boiling point of fluorine as 188 °C.

(d) (i) There were many correct responses. Some students, while realising that fluorine gained one electron omitted to explain why. A large number of students also attempted to consider the number of outer shell electrons on copper and the ratio of fluorine to copper atoms needed. A few students went on to explain the electrostatic attraction between the ions formed. Some students were limited to 1 mark as they suggested that electrons were shared.

(ii) There were many fully correct responses. The best students even named the precipitate as copper(II) hydroxide. Those gaining 1 mark generally failed to mention that the blue colour was due to a solid or precipitate, saying that it went blue, or the solution was blue. A variety of other reagents were added, including silver nitrate, indicators and acid. Some students thought electrolysis could be used to test for copper(II) ions. The flame test was a popular way of answering this which was given full credit even though the question asked for a chemical test.

36

(a) Only a very small minority of students were able to fully describe the structure and bonding without introducing an incorrect term, the most common of which was intermolecular. A large number of students included a description of the losing and gaining of an electron, or included the properties of an ionic compound. Students should be sure to read questions carefully, and answer the question which has been set.
Many students included covalent bonding in their response. Some students attempted to include iodine in their descriptions.

(b) Most students were able to name one of the products of electrolysis of sodium chloride solution, usually hydrogen. Non-creditworthy products frequently seen included sodium, water and carbon dioxide. Sodium oxide was also commonly seen.

(c) Only a minority of students gained credit. Harmful was commonly given, but not accepted unless qualified to indicate that too much iodine can be harmful. A significant minority of students suggested that iodine should not be added because it is unnatural, even suggesting that it is unnatural because it is a chemical.

(d) (i) There were many correct responses, with about two thirds of students gaining both marks. Of those gaining 1 mark, most gave the bonding electron pair correctly, but gave an incorrect number of non-bonding electrons. Some gave 2 bonding pairs.

(ii) Despite some excellent responses, this question proved challenging to many students, many of whom confused the strong covalent bonds within an iodine molecule with the weak intermolecular forces between the molecules. Some students referred to the weak intermolecular forces, but omitted to mention that iodine has simple molecules. There were many references to the reactivity of iodine, and its electron structure, especially the strength of attraction of electrons to the nucleus. Reference to weak covalent bonds negates any mention of intermolecular forces.

(iii) Most students gained the first marking point by identifying that iodine has no ions or delocalised electrons. However, only a few gained the second marking point for the idea that the ions or delocalised electrons are needed to carry charge.
Some students referred to the iodine being liquid, and stated that the particles were too far apart to conduct, and particles have to be closer (as in a solid) to collide and conduct electricity. This was not creditworthy.

40

(a) This question was a good discriminator. While many students recognised the presence of delocalised electrons in metals, the presence of atoms or positive ions was less well known, and the type of structure was frequently not given. Students continue to find the concept of the movement of electrons throughout the metal difficult to express. Misconceptions about the bonding in metals are still prevalent, including ionic and covalent bonding and intermolecular forces.

(b) This question discriminated well. Many succinct descriptions of the differences between a pure metal and an alloy were seen. Some students described properties or bonding rather than structural features. These points were not creditworthy.

(c) (i) Rather than recognising Nitinol as a shape memory alloy, many students gave a general property of alloys which did not relate specifically to Nitinol, for example it is strong, won‘t rust or is unreactive.

(ii) About half of all students gained this mark. There were many incorrect references to rusting and electrical conductivity. Many students have difficulty distinguishing between hardness and strength.

(iii) Only a minority of students gained credit. A wide range of incorrect responses was seen, including bauxite and aluminium ore.

(iv) While many students recognised that changing the reaction conditions (or a specific condition) would result in a different polymer, some students described properties that the different polymers might have, eg different densities (taken from the question), chain lengths and whether cross-linked. Some suggested that different products can be formed from a reversible reaction.

(d) A minority of students gained this mark. Some gave only one reason, and others explained why impurities in metal should be detected, not why instrumental methods are used. Many students suggested precision, reliability, human error, cost or ease of use for one of their two reasons. These were not creditworthy.

41

(a) (i) This was answered correctly by the majority of students.

(ii) Most students scored all three marks.

(b) (i) Most students were able to score both marks on this question. However, there was some confusion with the reaction of sodium with water (comments such as the magnesium forms a ball) and some students thought that fizzing, bubbling and effervescing were different things − answers such as effervescing and bubbling being common. Some students had difficulty with the spelling of “effervescing”. There is nothing wrong with using the term “fizzes” because the meaning is the same and it will gain the mark.

(ii) Many excellent and well written answers were seen describing in detail this salt preparation with very clear descriptions of the crucial points of adding excess magnesium and obtaining crystals from the final solution. However, it was common for students to specify that excess acid was required and a small, but significant, minority stated that the solution should be evaporated to dryness.

Some students did not plan their answers, and arrows showing where things that had been missed out should be inserted were commonly seen. Some students gave overly detailed answers, focusing on the irrelevant and missing out the important steps in the process. At this level there is no need to explain how to light a Bunsen burner, or how to arrange apparatus using a gauze and tripod so something can be heated. Apparatus lists are not required, but correctly named apparatus needs to be linked to where it is used in the method. Despite the instruction in the stem, lists of safety precautions were also given.

42

(a) All parts of this question were answered correctly by the majority of students. Part (iii) proved the most demanding with a significant proportion of students selecting the structure of sodium chloride as an element.

(b) All parts of this question were answered correctly by the majority of students.

44

(a) A large majority of responses gained at least one mark, usually for the recognition that delocalised or free electrons have a role in electrical conductivity. A commonly seen incorrect response suggested that particles vibrating or colliding passed an electrical charge through the metal. It would appear that these students are confusing electrical conduction with conduction of heat.

(b) Some students were able to clearly explain the relevant structural features and bonding in diamond. Other students found it difficult to express that each atom forms four bonds, although this was a popular response. Some remembered the terms “lattice” or “giant structure”. Many students were limited to a maximum of one mark by referring to intermolecular forces, often as an unfortunate afterthought, sometimes describing them as “strong” and sometimes as “weak”.

(c) Many students gained only the first marking point because they did not explain why thermosetting polymers do not melt when heated. Some students suggested that thermosetting polymers would not conduct heat so well, so would be safer to use as saucepan handles. A number of students referred to the cross-links in thermosetting polymers as strong intermolecular forces. They are covalent bonds, not intermolecular forces which limited them to a maximum of one mark.