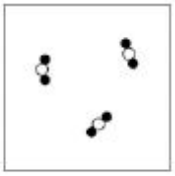
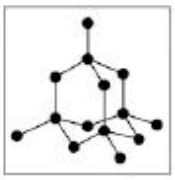
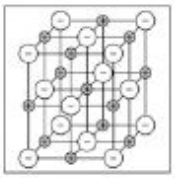
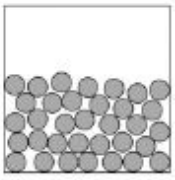
1 This question is about different substances and their structures.

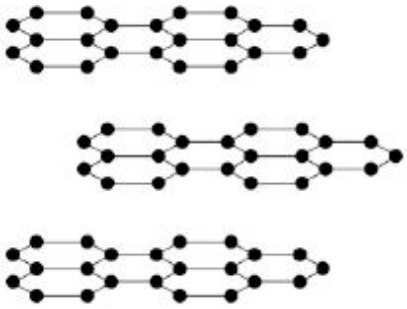
(a) Draw **one** line from each statement to the diagram which shows the structure.

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

(4)

(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 ☐

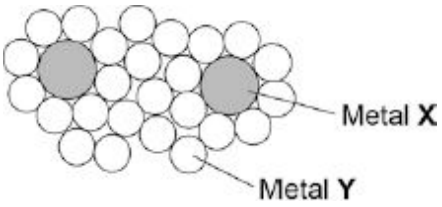
It has weak forces between the layers ☐

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 ☐

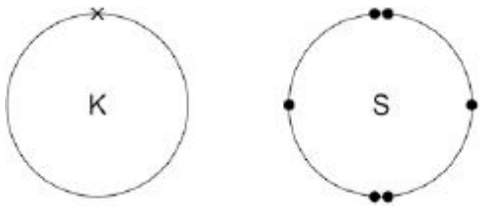
Element ☐

Mixture ☐

(1)
(Total 11 marks)

2 **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.

.....

.....

.....

.....

.....

.....

.....

.....

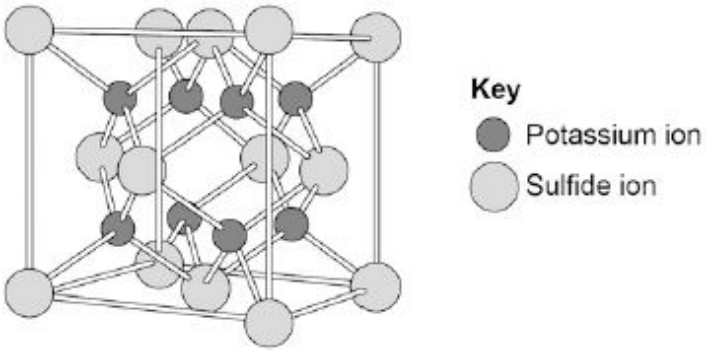
.....

.....

(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.

.....

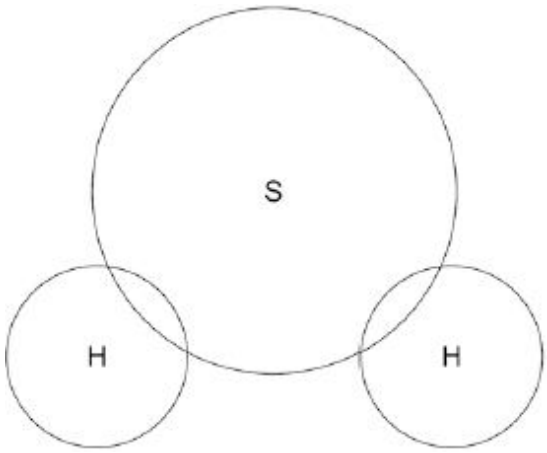
.....

(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**
Low melting point	There are no charged particles free to move
Does not conduct electricity when molten	Weak intermolecular forces of attraction

Electrons are free to move

Ions are free to move

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)

3 This question is about the reaction of ethene and bromine.

The equation for the reaction is:

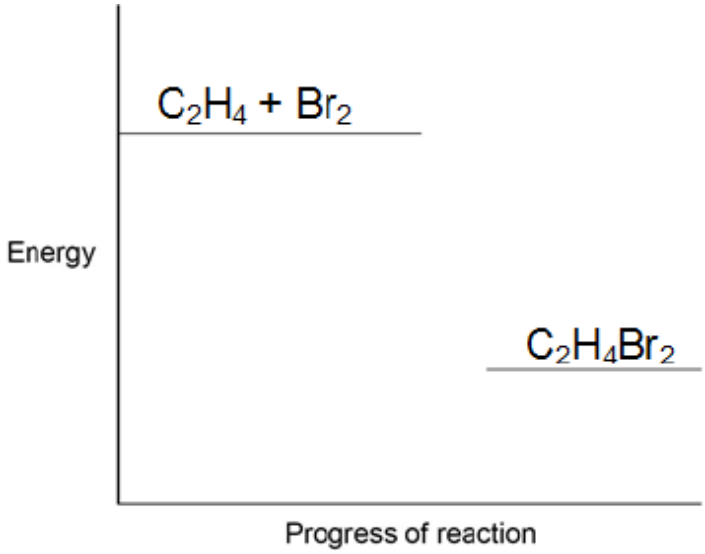
$$C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$$

(a) Complete the reaction profile in **Figure 1**.

Draw labelled arrows to show:

- The energy given out (ΔH)
- The activation energy.

Figure 1



(3)

(b) When ethene reacts with bromine, energy is required to break covalent bonds in the molecules.

Explain how a covalent bond holds two atoms together.

.....

.....

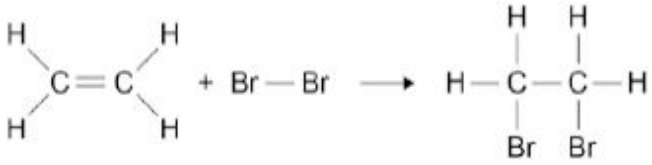
.....

.....

(2)

(c) **Figure 2** shows the displayed formulae for the reaction of ethene with bromine.

Figure 2



The bond enthalpies and the overall energy change are shown in the table below.

	C=C	**C–H**	**C–C**	**C–Br**	**Overall energy change**
Energy in kJ / mole	612	412	348	276	−95

Use the information in the table above and **Figure 2** to calculate the bond energy for the Br–Br bond.

.....

.....

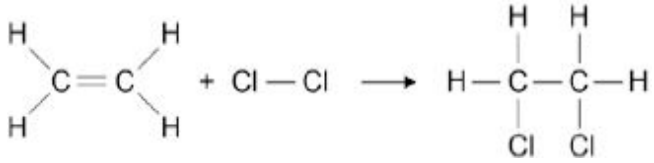
.....

Bond energy ..... kJ / mole

(3)

(d) **Figure 3** shows the reaction between ethene and chlorine and is similar to the reaction between ethene and bromine.

Figure 3



"The more energy levels (shells) of electrons an atom has, the weaker the covalent bonds that it forms."

Use the above statement to predict and explain how the overall energy change for the reaction of ethene with chlorine will differ from the overall energy change for the reaction of ethene with bromine.

.....

.....

.....

.....

.....

.....

.....

.....

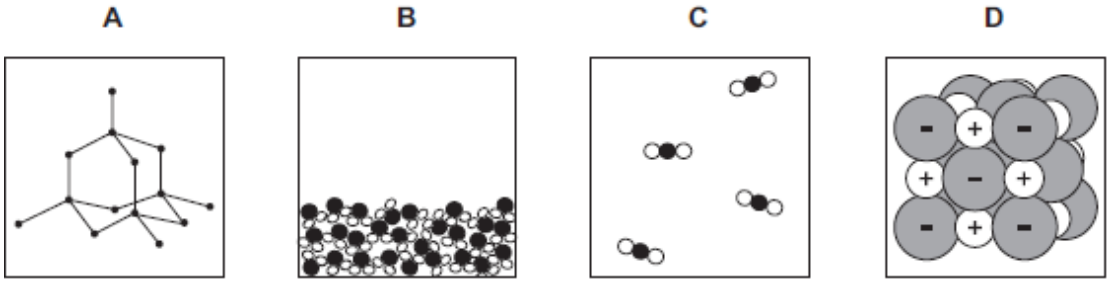
.....

.....

(6)
(Total 14 marks)

4 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? ☐

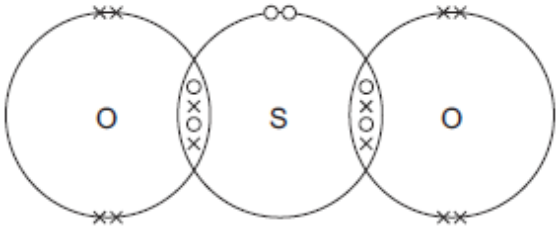
(1)

(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**?

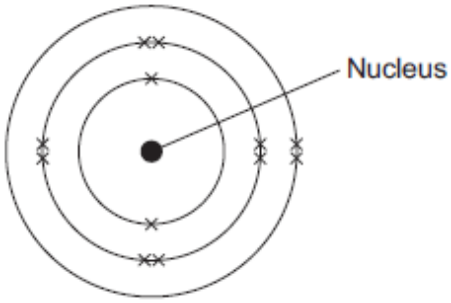
Draw a ring around the correct answer.

covalent **ionic** **metallic**

(1)
(Total 7 marks)

5 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 .....

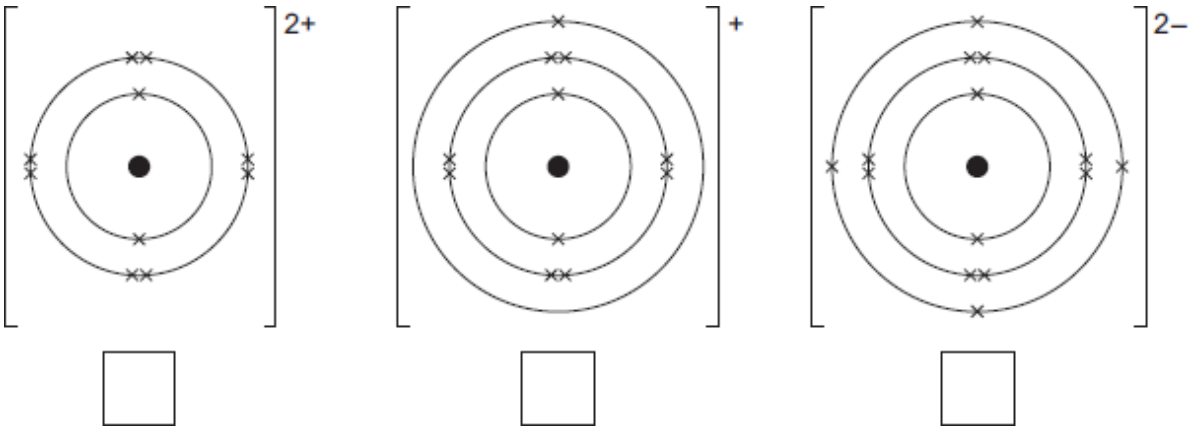
Atoms of magnesium are neutral because they contain the same number of electrons and .....

(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)

6 This question is about copper.

(a) Copper can be extracted by smelting copper-rich ores in a furnace.

The equation for one of the reactions in the smelting process is:

$$Cu_2S(s) + O_2(g) \longrightarrow 2\ Cu(s) + SO_2(g)$$

Explain why there would be an environmental problem if sulfur dioxide gas escaped into the atmosphere.

.....

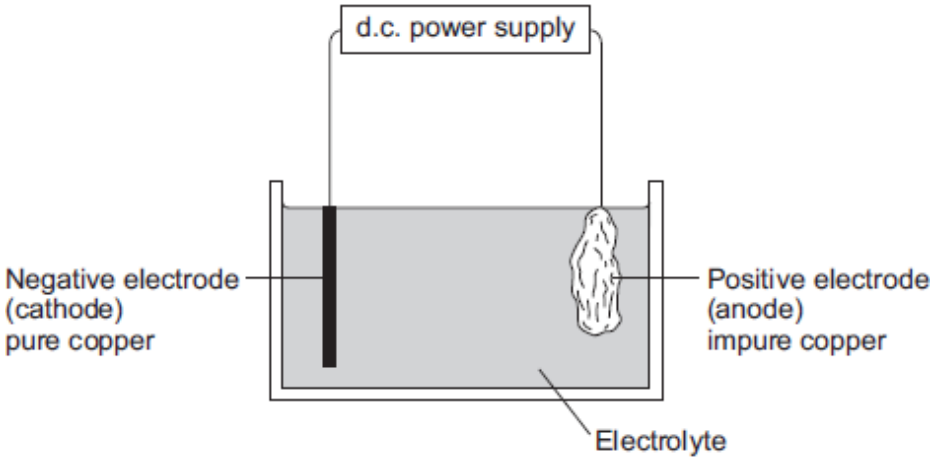
.....

.....

.....

(2)

(b) The impure copper produced by smelting is purified by electrolysis, as shown below.



Copper atoms are oxidised at the positive electrode to Cu^{2+} ions, as shown in the half equation.

$$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$$

(i) How does the half equation show that copper atoms are oxidised?

.....

.....

(1)

(ii) The Cu^{2+} ions are attracted to the negative electrode, where they are reduced to produce copper atoms.

Write a balanced half equation for the reaction at the negative electrode.

.....

(1)

(iii) Suggest a suitable electrolyte for the electrolysis.

.....

(1)

(c) Copper metal is used in electrical appliances.

Describe the bonding in a metal, and explain why metals conduct electricity.

.....

.....

.....

.....

.....

.....

.....

.....

.....

(4)

(d) Soil near copper mines is often contaminated with low percentages of copper compounds.

Phytomining is a new way to extract copper compounds from soil.

Describe how copper compounds are extracted by phytomining.

.....

.....

.....

.....

.....

.....

(3)

(e) A compound in a copper ore has the following percentage composition by mass:

55.6% copper, 16.4% iron, 28.0% sulfur.

Calculate the empirical formula of the compound.

Relative atomic masses (A_r): S = 32; Fe = 56; Cu = 63.5

You must show all of your working.

.....

.....

.....

.....

.....

.....

.....

.....

Empirical formula = ...

(4)

(Total 16 marks)

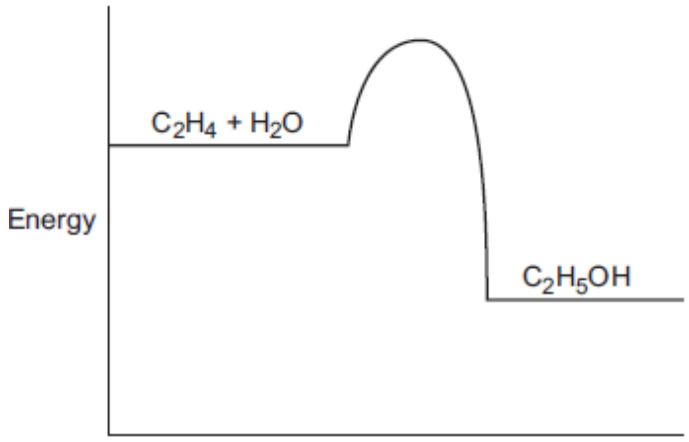
7 This question is about ethanol.

(a) Ethanol is produced by the reaction of ethene and steam:

$$C_2H_4 + H_2O \longrightarrow C_2H_5OH$$

(i) **Figure 1** shows the energy level diagram for the reaction.

Figure 1



How does the energy level diagram show that the reaction is exothermic?

.....

.....

(1)

(ii) A catalyst is used for the reaction.

Explain how a catalyst increases the rate of the reaction.

.....

.....

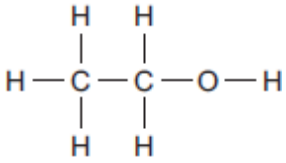
.....

.....

(2)

(b) **Figure 2** shows the displayed structure of ethanol.

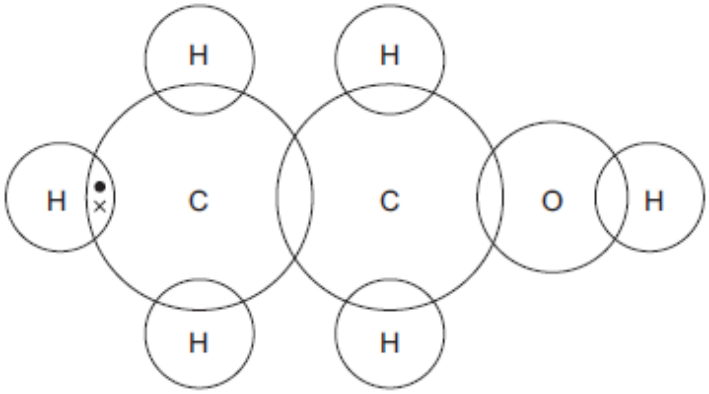
Figure 2



Complete the dot and cross diagram in **Figure 3** to show the bonding in ethanol.

Show the outer shell electrons only.

Figure 3

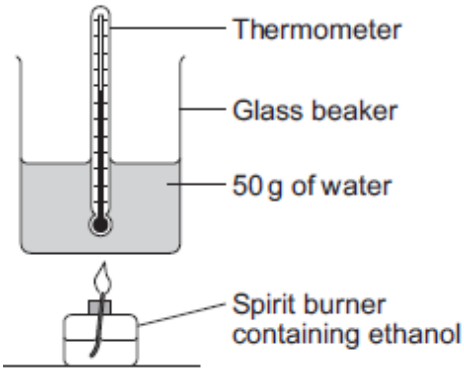


(2)

(c) A student burned some ethanol.

Figure 4 shows the apparatus the student used.

Figure 4



(i) The student recorded the temperature of the water before and after heating.

His results are shown in **Table 1**.

Table 1

Temperature before heating	20.7 °C
Temperature after heating	35.1 °C

Calculate the energy used to heat the water.

Use the equation $Q = m \times c \times \Delta T$

The specific heat capacity of water = 4.2 J / g / °C

.....

.....

.....

.....

.....

Energy used = ... J

(3)

(ii) **Table 2** shows the mass of the spirit burner before the ethanol was burned and after the ethanol was burned.

Table 2

Mass of spirit burner before ethanol was burned	72.80 g
Mass of spirit burner after ethanol was burned	72.10 g

Calculate the number of moles of ethanol (C_2H_5OH) that were burned.

Relative atomic masses (A_r): H = 1; C = 12; O = 16

.....

.....

.....

.....

.....

Number of moles burned = ...

(3)

(iii) Calculate the energy released in joules per mole.

You should assume that all the energy from the ethanol burning was used to heat the water.

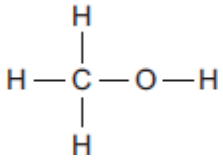
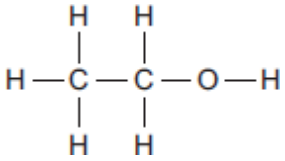
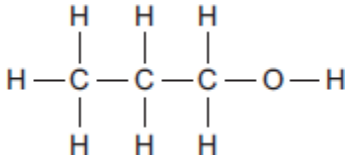
.....

Energy = ... J / mole

(1)

(d) The names, structures and boiling points of ethanol and two other alcohols are shown in **Table 3**.

Table 3

Name	**Methanol**	**Ethanol**	**Propanol**
Structure			
Boiling point in °C	65	78	97

Use your knowledge of structure and bonding to suggest why the boiling points increase as the number of carbon atoms increases.

.....

.....

.....

.....

.....

.....

.....

(3)
(Total 15 marks)

8 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.

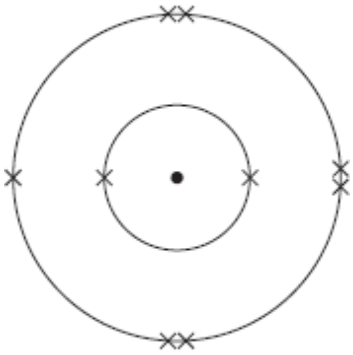
In order of increasing atomic number ☐

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.

.....

.....

.....

.....

.....

(2)

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

.....

.....

.....

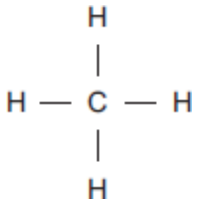
.....

.....

(2)
(Total 9 marks)

9 Methane (CH_4) is used as a fuel.

(a) The displayed structure of methane is:



Draw a ring around a part of the displayed structure that represents a covalent bond.

(1)

(b) Why is methane a compound?

Tick (✓) **one** box.

Methane contains atoms of two elements, combined chemically. ☐

Methane is not in the periodic table. ☐

Methane is a mixture of two different elements. ☐

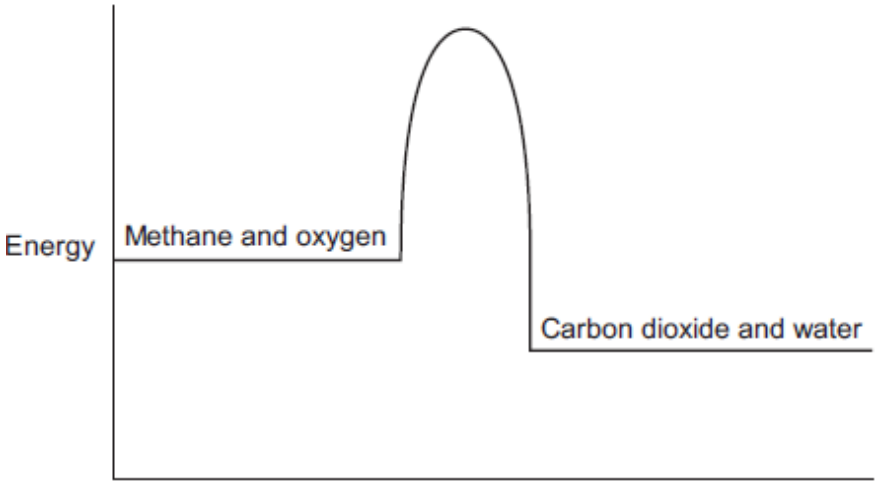
(1)

(c) Methane burns in oxygen.

(i) The diagram below shows the energy level diagram for the complete combustion of methane.

Draw and label arrows on the diagram to show:

- the activation energy
- the enthalpy change, ΔH.



(2)

(ii) Complete and balance the symbol equation for the complete combustion of methane.

$$CH_4 + \text{.....} \longrightarrow CO_2 + \text{.....}$$

(2)

(iii) Explain why the **incomplete** combustion of methane is dangerous.

.....

.....

.....

.....

(2)

(iv) Explain why, in terms of the energy involved in bond breaking and bond making, the combustion of methane is exothermic.

.....

.....

.....

.....

.....

.....

(3)

(d) Methane reacts with chlorine in the presence of sunlight.

The equation for this reaction is:

Some bond dissociation energies are given in the table.

Bond	**Bond dissociation energy in kJ per mole**
C−H	413
C−Cl	327
Cl−Cl	243
H−Cl	432

(i) Show that the enthalpy change, ΔH, for this reaction is −103 kJ per mole.

.....

.....

.....

.....

.....

.....

(3)

(ii) Methane also reacts with bromine in the presence of sunlight.

This reaction is less exothermic than the reaction between methane and chlorine.

The enthalpy change, ΔH, is −45 kJ per mole.

What is a possible reason for this?

Tick (✓) **one** box.

CH_3Br has a lower boiling point than CH_3Cl ☐

The C−Br bond is weaker than the C−Cl bond. ☐

The H−Cl bond is weaker than the H−Br bond. ☐

Chlorine is more reactive than bromine. ☐

(1)

(Total 15 marks)

10 This question is about salts.

(a) Salt (sodium chloride) is added to many types of food.

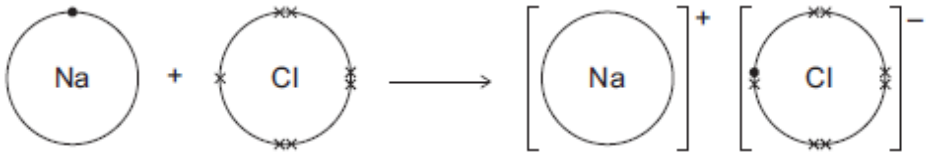
Sodium chloride is produced by reacting sodium with chlorine.

sodium + chlorine ⟶ sodium chloride

The diagram shows what happens to atoms of sodium and chlorine in this reaction.

The dots (•) and crosses (×) represent electrons.

Only the outer electrons are shown.



Describe, in terms of electrons, what happens when a sodium atom reacts with a chlorine atom to produce sodium chloride.

.....

.....

.....

.....

.....

.....

(3)

(b) Lack of iodine can affect the learning ability of children.

One idea is that salt (sodium chloride) should have iodine added.

(i) Iodine consists of simple molecules.

What is a property of substances that have simple molecules?

Tick (✓) **one** box.

Have no overall electric charge ☐

Have high boiling points ☐

Have giant covalent structures ☐

(1)

(ii) Which one of the following questions cannot be answered by science alone?

Tick (✓) **one** box.

How much sodium chloride is in food? ☐

What harm does a lack of iodine do? ☐

Should iodine be added to salt in food? ☐

Give **one** reason why this question cannot be answered by science alone.

.....

.....

(2)

(c) A student produced the salt ammonium nitrate by adding an acid to ammonia solution.

(i) Name the acid used.

.....

(1)

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

an acid	**an alkali**	**a salt**

Ammonia solution (ammonium hydroxide) is ..... .

(1)

(iii) The student added a few drops of a solution which changed colour when the reaction was complete.

Complete the sentence.

The solution added is an ..... .

(1)

(d) Farmers buy solid ammonium nitrate in poly(ethene) sacks.

(i) How is solid ammonium nitrate made from a solution of ammonium nitrate?

Tick (✓) **one** box.

Crystallisation ☐

Decomposition ☐

Electrolysis ☐

(1)

(ii) Why do farmers use ammonium nitrate on their fields?

.....

.....

(1)

(iii) The properties of poly(ethene) depend on the reaction conditions when it is made.

State **one** reaction condition that can be changed when making poly(ethene).

.....

.....

(1)
(Total 12 marks)

11 This question is about electrolysis.

(a) Metal spoons can be coated with silver.
This is called electroplating.

Suggest **one** reason why spoons are electroplated.

.....

.....

(1)

(b) When sodium chloride solution is electrolysed the products are hydrogen and chlorine.

(i) What is made from chlorine?

Tick (✓) **one** box.

Bleach ☐

Fertiliser ☐

Soap ☐

(1)

(ii) Sodium chloride solution contains two types of positive ions, hydrogen ions (H^+) and sodium ions (Na^+).

Why is hydrogen produced at the negative electrode and **not** sodium?

Tick (✓) **one** box.

Hydrogen is a gas. ☐

Hydrogen is less reactive than sodium. ☐

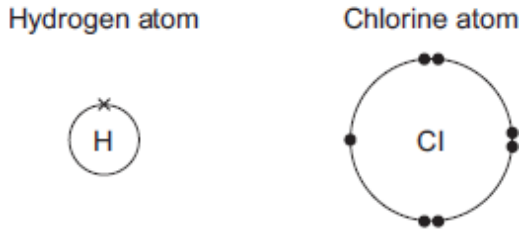
Hydrogen ions move faster than sodium ions. ☐

(1)

(iii) Hydrogen and chlorine can be used to produce hydrogen chloride.

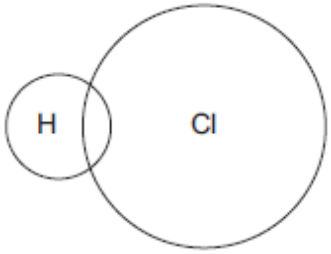
The diagrams in **Figure 1** show how the outer electrons are arranged in an atom of hydrogen and an atom of chlorine.

Figure 1



Complete **Figure 2** to show how the outer electrons are arranged in a molecule of hydrogen chloride (HCl).

Figure 2



(1)

(iv) What is the type of bond in a molecule of hydrogen chloride?

Tick (✓) **one** box.

Covalent ☐

Ionic ☐

Metallic ☐

(1)

(v) Why is hydrogen chloride a gas at room temperature (20 °C)?

Tick (✓) **two** boxes.

Hydrogen chloride has a low boiling point. ☐

Hydrogen chloride has a high melting point. ☐

Hydrogen chloride is made of simple molecules. ☐

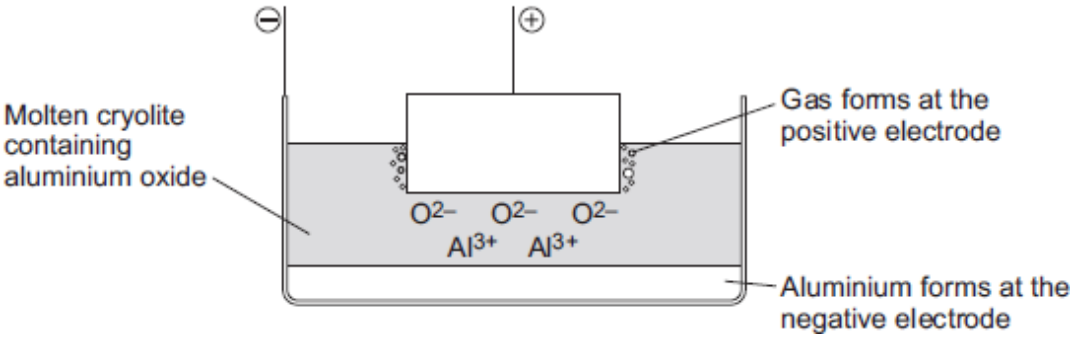
Hydrogen chloride does not conduct electricity. ☐

Hydrogen chloride has a giant structure. ☐

(2)

(c) Aluminium is produced by electrolysis of a molten mixture of aluminium oxide and cryolite. This is shown in **Figure 3**.

Figure 3



(i) Name a gas produced at the positive electrode.

.....

(1)

(ii) Aluminium ions move to the negative electrode.

Explain why.

.....

.....

.....

.....

(2)

(iii) At the negative electrode, the aluminium ions gain electrons to produce aluminium.

What is this type of reaction called?

Tick (✓) **one** box.

Combustion ☐

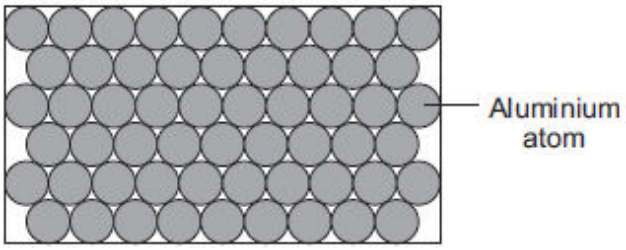
Oxidation ☐

Reduction ☐

(1)

(iv) Aluminium has layers of atoms, as shown in **Figure 4**.

Figure 4



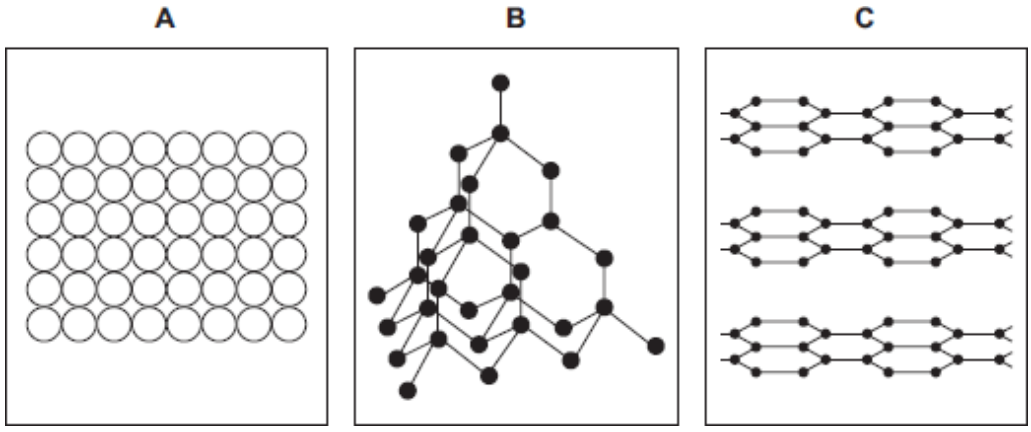
Complete the sentence.

Metals can be bent and shaped because the layers of atoms can .....

(1)

(d) Electrodes used in the production of aluminium are made from graphite.

(i) Which diagram, **A, B** or **C**, shows the structure of graphite?



The structure of graphite is shown in diagram ☐

(1)

(ii) The temperature for the electrolysis is 950 °C.

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

cross links	**a giant ionic lattice**	**strong covalent bonds**

The graphite does not melt at 950 °C because

graphite has ..... .

(1)

(Total 14 marks)

12 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)

13 This question is about compounds.

(a) The table gives information about the solubility of some compounds.

Soluble compounds
All potassium and sodium salts
All nitrates
Chlorides, bromides and iodides, except those of silver and lead

Use information from the table to answer these questions.

(i) Name a soluble compound that contains silver ions.

.....

(1)

(ii) Name a soluble compound that contains carbonate ions.

.....

(1)

(b) Metal oxides react with acids to make salts.

What type of compound is a metal oxide?

.....

(1)

(c) Lead nitrate solution is produced by reacting lead oxide with nitric acid.

(i) State how solid lead nitrate can be obtained from lead nitrate solution.

.....

.....

(1)

(ii) Balance the equation for the reaction.

$$PbO + HNO_3 \longrightarrow Pb(NO_3)_2 + H_2O$$

(1)

(iii) Give the total number of atoms in the formula $Pb(NO_3)_2$

.....

(1)

(d) An oxide of lead that does **not** have the formula PbO contains 6.21 g of lead and 0.72 g of oxygen.

Calculate the empirical formula of this lead oxide.

Relative atomic masses (A_r): O = 16; Pb = 207

You must show your working to gain full marks.

.....

.....

.....

.....

.....

.....

Empirical formula = ...

(4)

(Total 10 marks)

14 This question is about sodium chloride and iodine.

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

.....

.....

.....

.....

.....

.....

.....

.....

(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.

.....

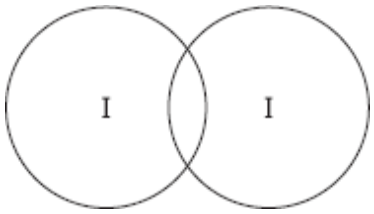
.....

(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.

.....

.....

.....

.....

.....

.....

(3)

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

.....

.....

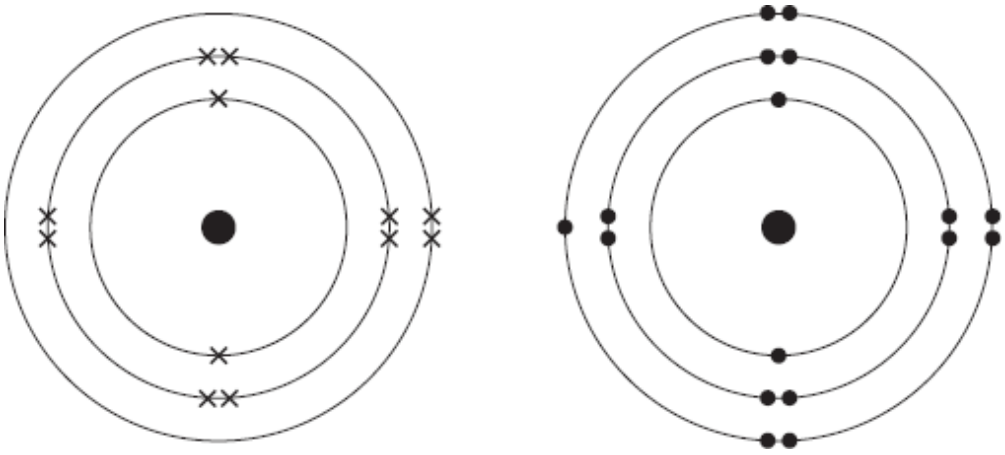
.....

.....

(2)

(Total 14 marks)

15 (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 ($MgCl_2$).

.....

.....

.....

.....

.....

.....

.....

.....

(4)

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

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

.....

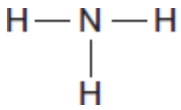
.....

.....

Relative formula mass (M_r) = ...

(2)
(Total 6 marks)

16 (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.

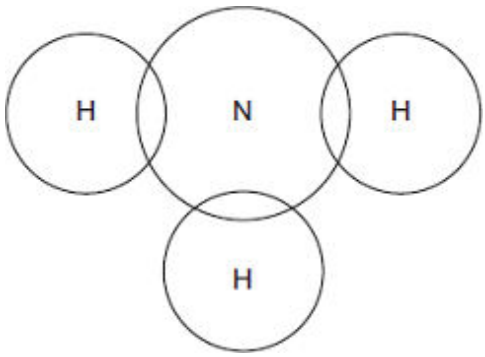
A particle of ammonia is called

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.

$$NH_3(g) + HCl(.....) \longrightarrow NH_4Cl(.....)$$

(1)

(ii) The white solid has the formula NH_4Cl

Complete the name of the white solid.

Ammonium .....

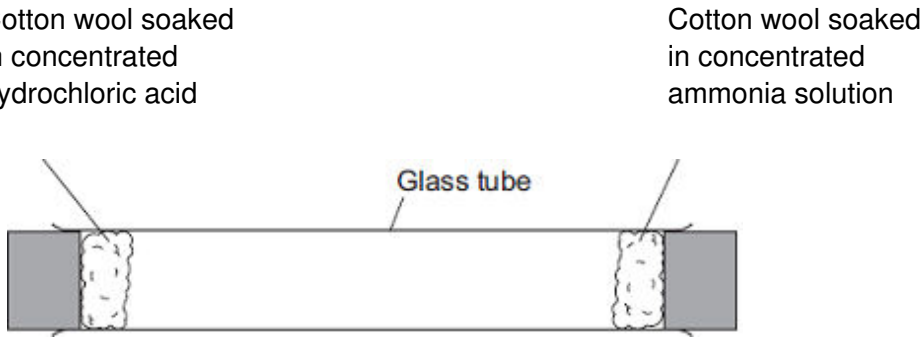
(1)

(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.

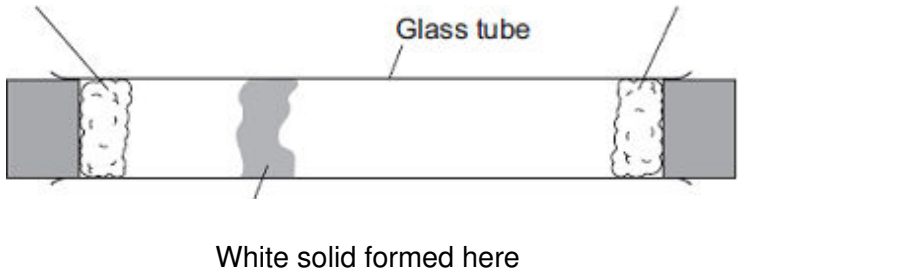
.....

.....

(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.

.....

.....

.....

.....

(2)
(Total 10 marks)

17 Sulfur is a non-metal.

Sulfur burns in the air to produce sulfur dioxide, SO_2

(a) Why is it important that sulfur dioxide is **not** released into the atmosphere?

Tick (✓) **one** box.

Sulfur dioxide causes acid rain. ☐

Sulfur dioxide causes global dimming. ☐

Sulfur dioxide causes global warming. ☐

(1)

(b) Sulfur dioxide dissolves in water.

What colour is universal indicator in a solution of sulfur dioxide?
Give a reason for your answer.

.....

.....

.....

.....

(2)

(c) Sulfur dioxide is a gas at room temperature.

The bonding in sulfur dioxide is covalent.

Explain, in terms of its structure and bonding, why sulfur dioxide has a low boiling point.

.....

.....

.....

.....

.....

.....

(3)

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

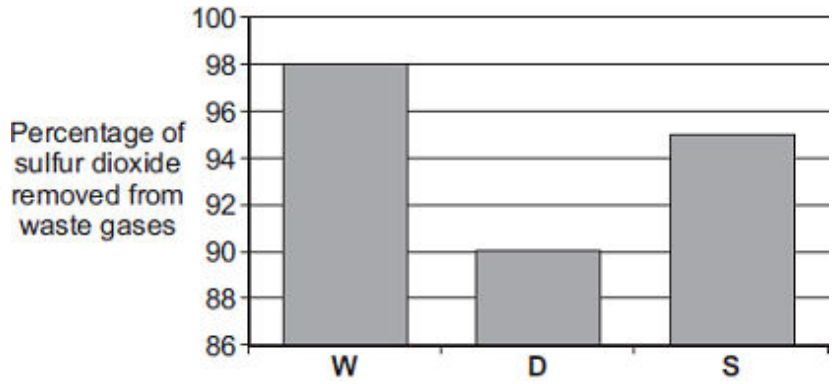
Sulfur dioxide is produced when fossil fuels are burned.

It is important that sulfur dioxide is not released into the atmosphere.

Three of the methods used to remove sulfur dioxide from gases produced when fossil fuels are burned are:

- wet gas desulfurisation (**W**)
- dry gas desulfurisation (**D**)
- seawater gas desulfurisation (**S**).

Information about the three methods is given in the bar chart and in **Table 1** and **Table 2**.



Method of removing sulfur dioxide

Table 1

Method	Material used	How material is obtained
W	Calcium carbonate, $CaCO_3$	Quarrying
D	Calcium oxide, CaO	Thermal decomposition of calcium carbonate: $CaCO_3 \longrightarrow CaO + CO_2$
S	Seawater	From the sea

Table 2

Method	What is done with waste material
W	Solid waste is sold for use in buildings. Carbon dioxide is released into the atmosphere.
D	Solid waste is sent to landfill.
S	Liquid waste is returned to the sea.

Evaluate the three methods of removing sulfur dioxide from waste gases.

Compare the three methods and give a justified conclusion.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

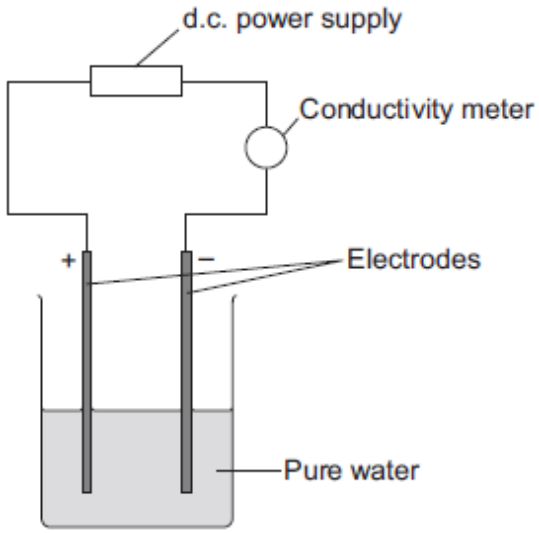
.....

.....

(6)
(Total 12 marks)

18 A student investigated the conductivity of different concentrations of sodium chloride solution.
The student set the apparatus up as shown in **Figure 1**.

Figure 1



The student measured the conductivity of the pure water with a conductivity meter.

The reading on the conductivity meter was zero.

(a) The student:

- added sodium chloride solution one drop at a time
- stirred the solution
- recorded the reading on the conductivity meter.

The student's results are shown in the table below.

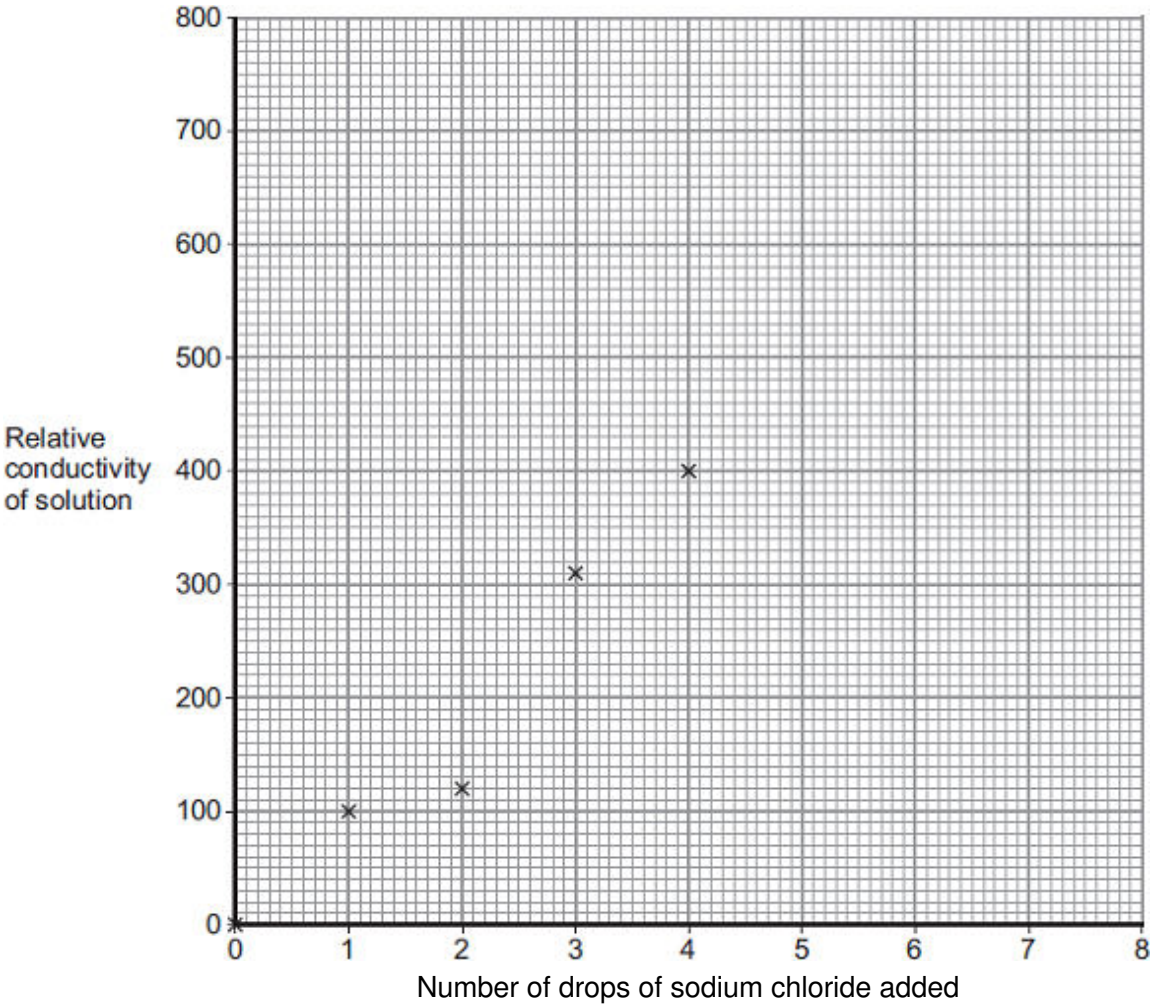
Number of drops of sodium chloride solution added	Relative conductivity of solution
0	0
1	100
2	120
3	310
4	400
5	510
6	590
7	710
8	800

(i) The student plotted the results on the grid shown in **Figure 2**.

Plot the four remaining results.

Draw a line of best fit, ignoring the anomalous result.

Figure 2



(3)

(ii) One of the points is anomalous.

Suggest **one** error that the student may have made to cause the anomalous result.

.....

.....

(1)

(iii) The student wanted to compare the conductivity of sodium chloride solution with the conductivity of potassium chloride solution.

State **one** variable he should keep constant when measuring the conductivity of the two solutions.

.....

(1)

(b) (i) Explain, in terms of bonding, why pure water does **not** conduct electricity.

.....

.....

.....

.....

(2)

(ii) Explain why sodium chloride solution conducts electricity.

.....

.....

.....

.....

(2)

(iii) After he had added sodium chloride solution, the student noticed bubbles of gas at the negative electrode.

Complete the sentence.

The gas produced at the negative electrode is .....

(1)

(Total 10 marks)

19 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

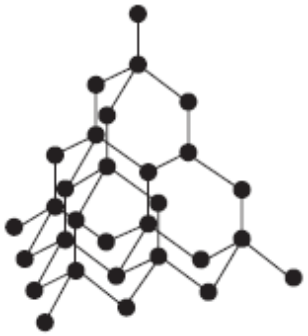
(1)

(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)

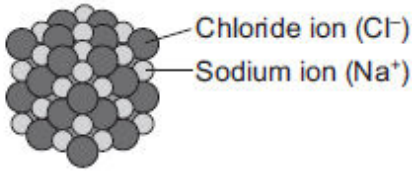
20 **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

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

Chlorine

Cl — Cl

Sodium chloride



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

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Extra space .....

.....

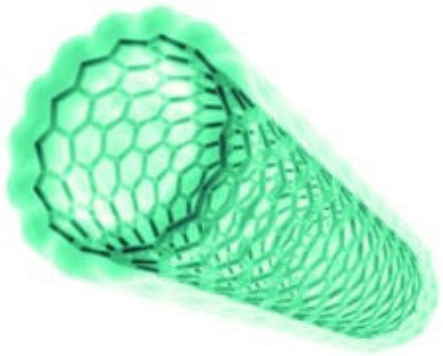
.....

.....

.....

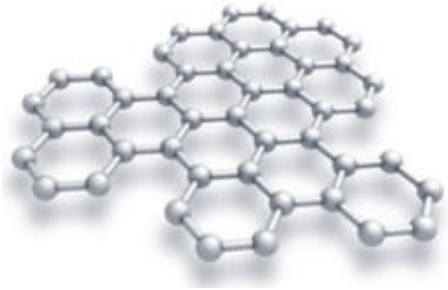
(Total 6 marks)

21 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.

.....

.....

.....

.....

(2)

(b) Explain why graphite can conduct electricity.

.....

.....

.....

.....

(2)
(Total 4 marks)

22 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.

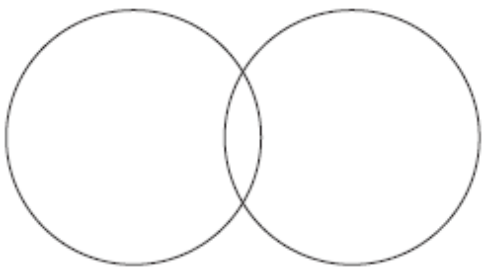
Give the formula of sodium oxide.

.....

(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.

.....

.....

.....

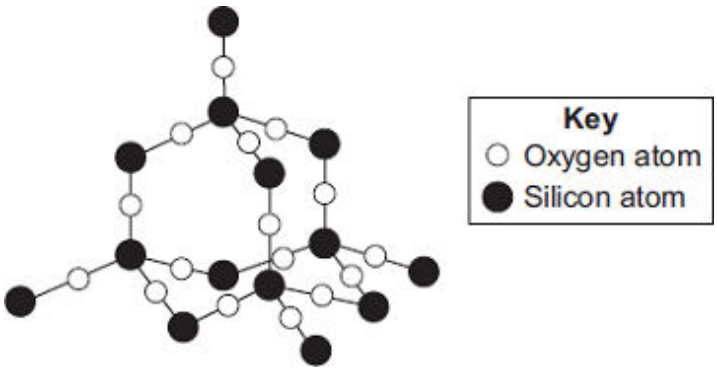
.....

.....

.....

(3)
(Total 7 marks)

23 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.

The bonds in silicon dioxide are [ionic. / covalent. / metallic.]

(2)

(b)

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)

24

Kelp is a seaweed.

Kelp can be burned to give out energy.

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

Reactions which give out energy are

endothermic.
exothermic.
reversible.

(1)

(b) Which **two** of the following questions **cannot** be answered by scientific experiments alone?

Tick (✓) **two** boxes.

Question	Tick (✓)
How much carbon dioxide is produced when 100 g of kelp is burned?	
Does kelp give out more heat energy than coal when burned?	
Should people use kelp instead of oil as an energy source?	
Will kelp be more popular than coal in the next 10 years?	

(2)

(c) Potassium iodide can be produced from kelp.

(i) Potassium can be reacted with iodine to produce potassium iodide.

potassium + iodine → potassium iodide

The diagram shows how this happens.

Only the outer electrons are shown.

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

Use the diagram to help you answer this question.

Describe, as fully as you can, what happens when potassium reacts with iodine to produce potassium iodide.

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

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(4)

(ii) Potassium iodide reacts with lead nitrate.

$2\ KI(aq) + Pb(NO_3)_2(aq) \rightarrow 2\ KNO_3(aq) + PbI_2(s)$

Why is this reaction a precipitation?

.....

.....

(1)

(iii) How can the precipitate be removed from the reaction mixture?

.....

.....

(1)

(Total 9 marks)

25 Thermosoftening polymers can be used to make plastic bottles and food packaging.

(a) Why are thermosoftening polymers **not** suitable for storing very hot food?

.....

.....

(1)

(b) The reaction to produce the polymers uses a catalyst.

Why are catalysts used in chemical reactions?

.....

.....

(1)

(c) Compounds from food packaging must not get into food.

Gas chromatography can be used to separate compounds in food.

The output from the gas chromatography column can be linked to an instrument which can identify the compounds.

(i) Name the instrument used to identify the compounds.

.....

.....

(1)

(ii) Give **one** reason why instrumental methods of analysis are used to identify the compounds.

.....

.....

(1)

(d) Poly(ethene) is a thermosoftening polymer.

Poly(ethene) can be made with different properties. The properties depend on the conditions used when poly(ethene) is made.

Suggest **two** conditions which could be changed when poly(ethene) is made.

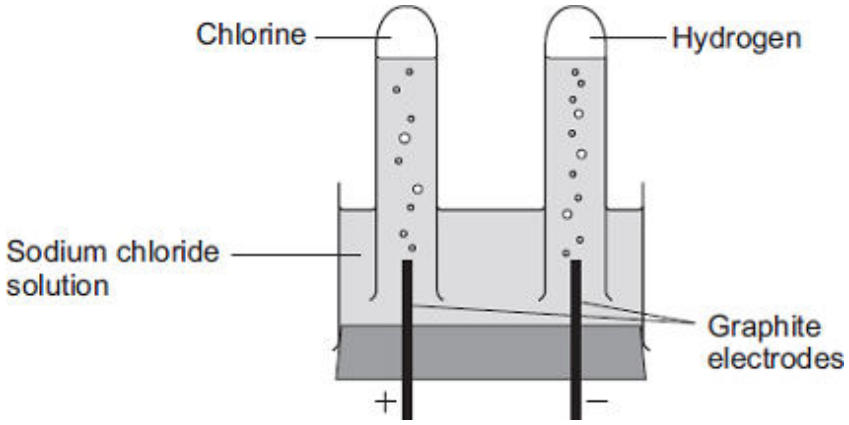
.....

.....

(2)
(Total 6 marks)

26 The electrolysis of sodium chloride solution is an industrial process.

The diagram shows the apparatus used in a school experiment.



(a) One of the products of the electrolysis of sodium chloride solution is hydrogen.

(i) Why do hydrogen ions move to the negative electrode?

.....

.....

(1)

(ii) How does a hydrogen ion change into a hydrogen atom?

.....

.....

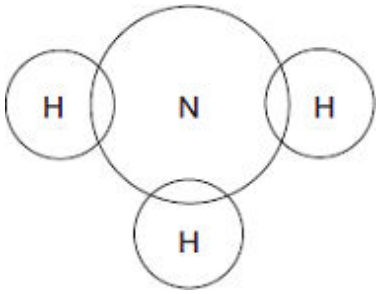
(1)

(b) Hydrogen is used to make ammonia (NH_3).

Complete the diagram to show the bonding in ammonia.

Use dots (●) and crosses (x) to show electrons.

Show only outer shell electrons.



(2)

(c) The table shows the ions in sodium chloride solution.

Positive ions	**Negative ions**
hydrogen	chloride
sodium	hydroxide

In industry, some of the waste from the electrolysis of sodium chloride solution is alkaline and has to be neutralised.

(i) Which ion makes the waste alkaline?

.....

(1)

(ii) This waste must be neutralised.

Write the ionic equation for the neutralisation reaction.

.....

(1)

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

The electrolysis of sodium chloride solution also produces chlorine and sodium hydroxide.

In industry, the electrolysis of sodium chloride solution can be done in several types of electrolysis cell.

Some information about two different types of electrolysis cell is given below.

	Mercury cell	**Membrane cell**
Cost of construction	Expensive	Relatively cheap
Additional substances used	Mercury, which is recycled. Mercury is toxic so any traces of mercury must be removed from the waste	Membrane, which is made of a polymer. The membrane must be replaced every 3 years.
Amount of electricity used for each tonne of chlorine produced in kWh	3400	2950
Quality of chlorine produced	Pure	Needs to be liquefied and distilled to make it pure.
Quality of sodium hydroxide solution produced	50% concentration. Steam is used to concentrate the sodium hydroxide solution produced.	30% concentration. Steam is used to concentrate the sodium hydroxide solution produced.

Use the information and your knowledge and understanding to compare the environmental and economic advantages and disadvantages of these **two** types of electrolysis cell.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(6)
(Total 12 marks)

27 Kelp is a seaweed.

Kelp can be used in foods and as a renewable energy source.

(a) Scientific experiments, on their own, **cannot** fully answer one of the following questions. Which one?

Tick (✓) **one** box.

Questions	Tick (✓)
How much carbon dioxide is produced when 100 g of kelp is burned?	
Does kelp give out more heat energy than coal?	
Will kelp last longer than coal as an energy source?	
Which fuel, kelp or coal, produces the most ash when burned?	

(1)

(b) Scientists cannot answer the question 'should people use kelp instead of coal as an energy source?'

Give **two** reasons why.

.....

.....

.....

.....

(2)

(c) Sodium iodide can be produced from kelp.

(i) How many electrons are in the outer shell of an iodine atom?

(1)

(ii) Sodium iodide contains sodium ions (Na^+) and iodide ions (I^-).

Describe, as fully as you can, what happens when sodium atoms react with iodine atoms to produce sodium iodide.

You may use a diagram in your answer

.....

.....

.....

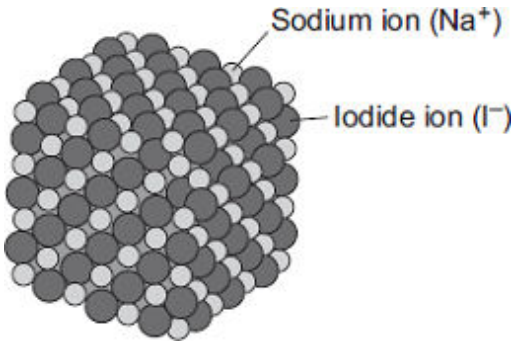
.....

.....

.....

(3)

(iii) The diagram shows the structure of sodium iodide.



Solid sodium iodide does not conduct electricity.

Why does sodium iodide solution conduct electricity?

.....

.....

(1)

(iv) When sodium iodide solution is electrolysed, iodine is formed at the positive electrode.

Complete and balance the half equation for the formation of iodine.

$$\text{.....}I^- \rightarrow I_2 + \text{.....}e^-$$

(1)

(v) What is formed at the negative electrode when sodium iodide solution is electrolysed?

Explain why.

.....

.....

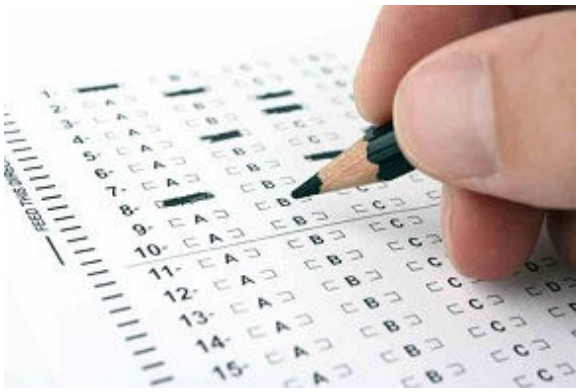
.....

.....

(2)

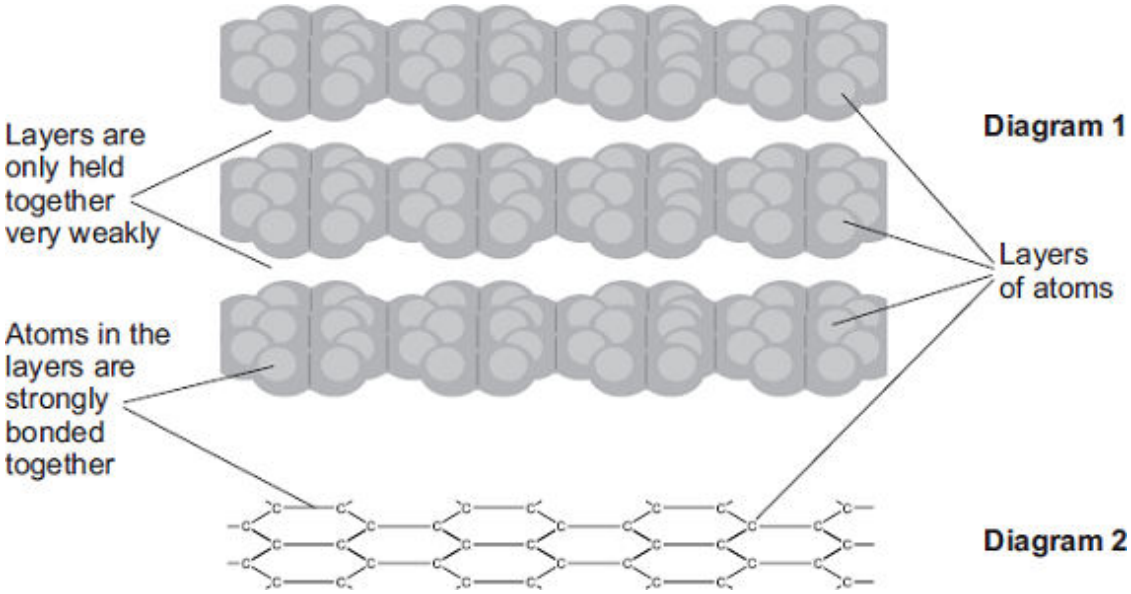
(Total 11 marks)

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



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.

.....

.....

.....

.....

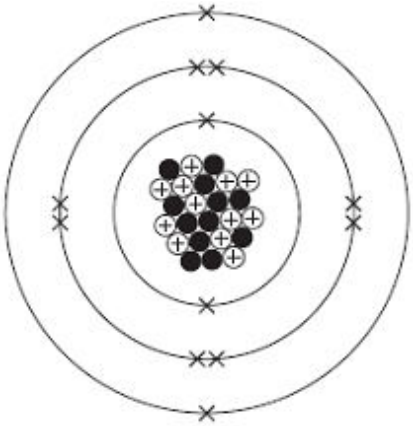
(2)

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

covalent **ionic** **metallic**

(1)
(Total 3 marks)

29 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.

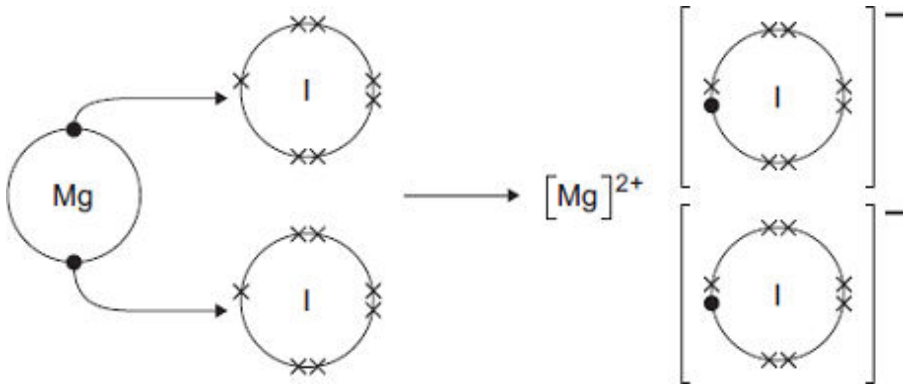
12 **24** **36**

(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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

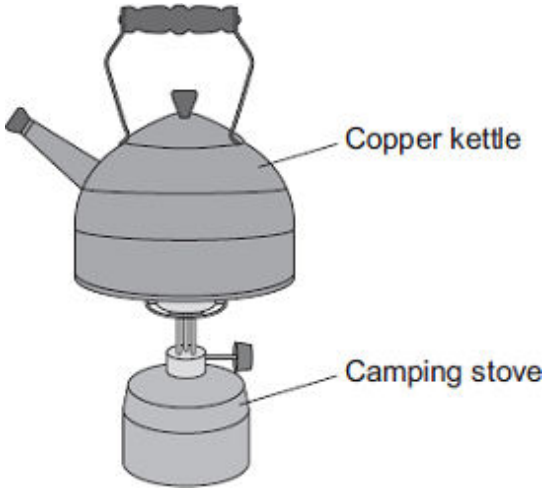
.....

(4)
(Total 9 marks)

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

Copper is a good material for making a kettle because:

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



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

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

.....

.....

.....

.....

.....

.....

.....

.....

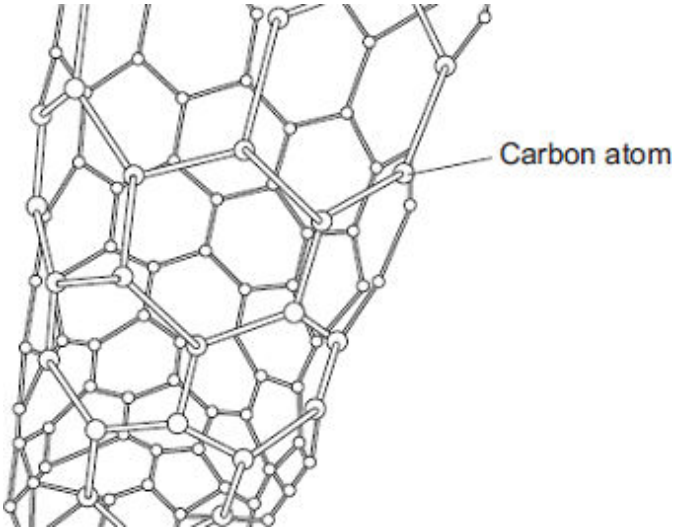
.....

(4)

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

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

The diagram shows the structure of a carbon nanotube.



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

.....

.....

(1)

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

Explain why the carbon nanotube can conduct electricity.

.....

.....

.....

.....

.....

(2)

(Total 7 marks)

31 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.

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

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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

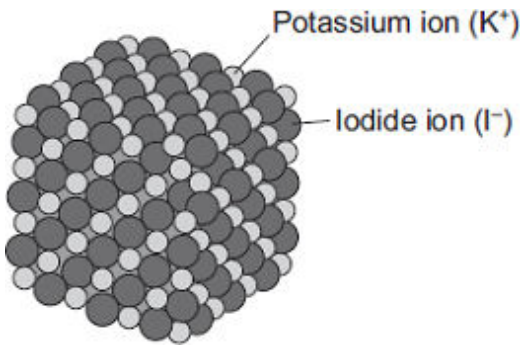
.....

.....

.....

(4)

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



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

.....

.....

.....

.....

.....

.....

(3)
(Total 9 marks)

32 This question is about lithium and sodium.

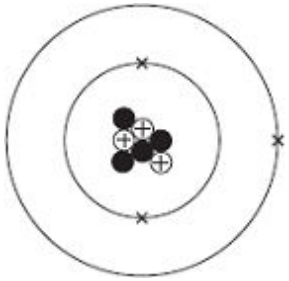
(a) Use the Chemistry Data Sheet to help you to answer this question.

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 ☐

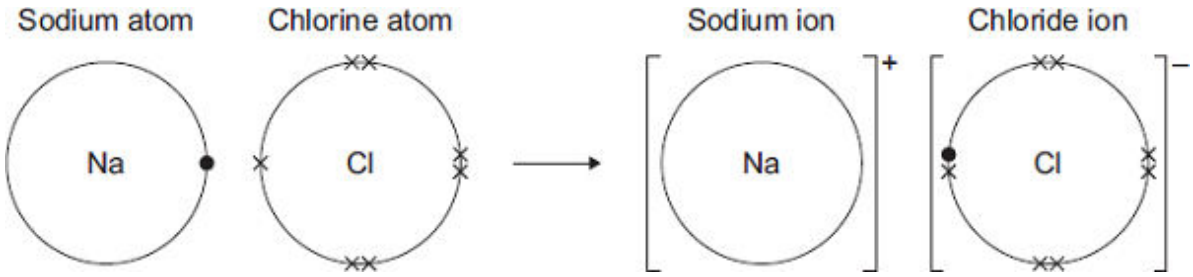
(1)

(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?

.....

.....

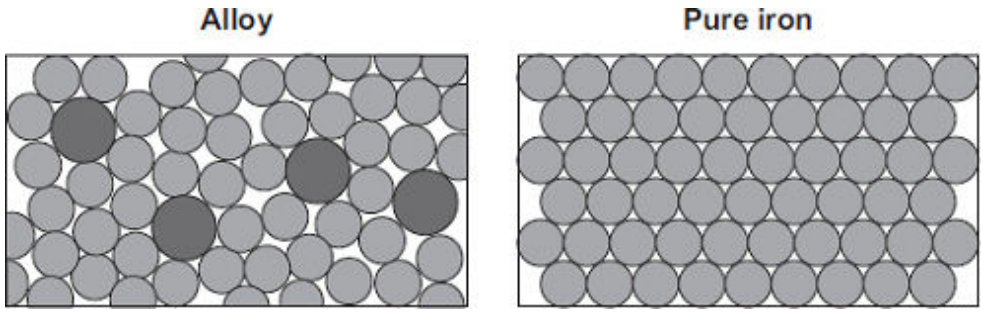
(1)
(Total 12 marks)

33 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)

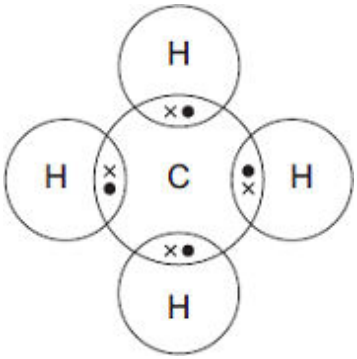
(b) Drill heads contain diamonds.

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)

34 Humphrey Davy was a professor of chemistry.

In 1807 Humphrey Davy did an electrolysis experiment to produce potassium.

(a) (i) Humphrey Davy was the first person to produce potassium.

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

Humphrey Davy's experiment to produce this new element was quickly accepted by

other scientists because he

had a lot of money.
had a lot of staff to help.
was well qualified.

(1)

(ii) Other scientists were able to repeat Davy's experiment.

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

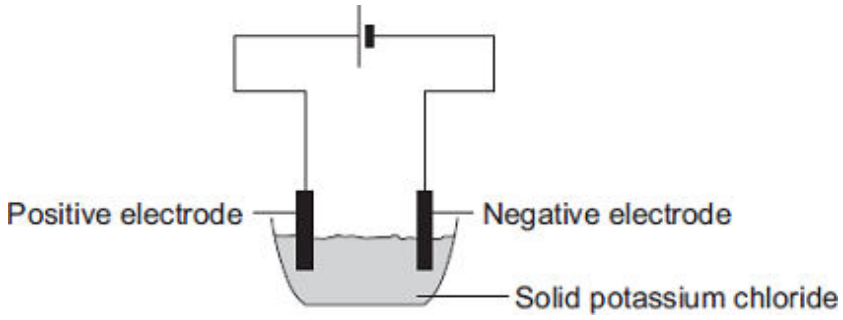
Being able to repeat Davy's experiment is important because

other scientists can

check the results of the experiment.
see if the experiment is safe.
take the credit for the discovery.

(1)

(b) A student tried to electrolyse potassium chloride.



Potassium chloride contains potassium ions (K^+) and chloride ions (Cl^-).

(i) The student found that solid potassium chloride does not conduct electricity.

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

are too big	**cannot move**	**have no charge**

Solid potassium chloride does not conduct electricity because

the ions ..... .

(1)

(ii) What could the student do to the potassium chloride to make it conduct electricity?

.....

(1)

(iii) During electrolysis why do potassium ions move to the negative electrode?

.....

(1)

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

When the potassium ions reach the negative electrode

they turn into potassium

atoms.
electrodes.
molecules.

(1)

(Total 6 marks)

35 Ammonia is produced from nitrogen and hydrogen.

The equation for this reaction is:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(a) (i) A company wants to make 6.8 tonnes of ammonia.

Calculate the mass of nitrogen needed.

Relative atomic masses (A_r): H = 1; N = 14

.....

.....

.....

.....

.....

Mass of nitrogen = ... tonnes

(3)

(ii) The company expected to make 6.8 tonnes of ammonia.

The yield of ammonia was only 4.2 tonnes.

Calculate the percentage yield of ammonia.

.....

.....

Percentage yield of ammonia = ... %

(2)

(iii) Use the equation above to explain why the percentage yield of ammonia was less than expected.

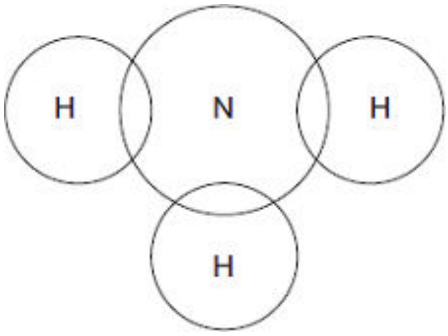
.....

.....

(1)

(b) Complete the diagram to show the arrangement of the outer shell electrons of the nitrogen and hydrogen atoms in ammonia.

Use dots (●) and crosses (x) to represent the electrons.



(2)

(c) Ammonia dissolves in water to produce an alkaline solution.

(i) Which ion makes ammonia solution alkaline?

.....

(1)

(ii) Name the type of reaction between aqueous ammonia solution and an acid.

.....

(1)

(iii) Name the acid needed to produce ammonium nitrate.

.....

(1)

(iv) The reaction of ammonia with sulfuric acid produces ammonium sulfate.

Use the formulae of the ions on the Chemistry Data Sheet.

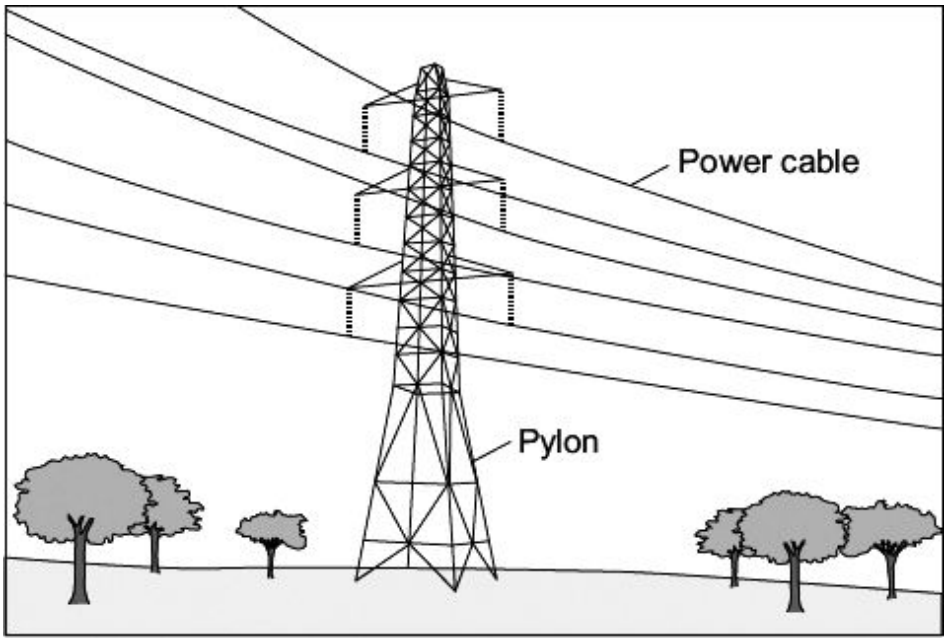
Write the formula of ammonium sulfate.

.....

(1)

(Total 12 marks)

36 Metals are used in the manufacture of pylons and overhead power cables.



(a) Suggest **one** reason why iron (steel) is used to make pylons.

.....

.....

(1)

(b) The table shows some of the properties of two metals.

Metal	Density in g per cm^3	Melting point in °C	Percentage(%) relative electrical conductivity	Percentage(%) abundance in Earth's crust
copper	8.92	1083	100	0.007
aluminium	2.70	660	60	8.1

Use the information in the table to suggest why aluminium and **not** copper is used to conduct electricity in overhead power cables.

.....

.....

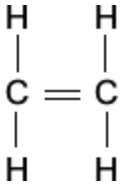
.....

.....

(2)

(c) A polymer can be used to cover and insulate power cables.

The polymer is made from the alkene:



Draw a ring around the correct answer to complete each of the sentences.

(i) The chemical formula of this alkene is

CH

CH_4

C_2H_4

(1)

(ii) The two lines between the carbon atoms are called a

double bond.

nucleus.

single bond.

(1)

(iii) The name of the polymer formed when many of these alkene molecules join together is

poly(ethene).

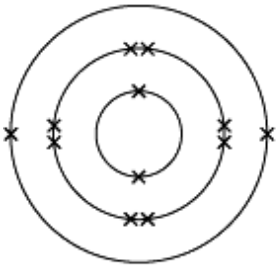
poly(ethenol).

poly(propene).

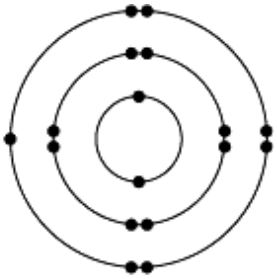
(1)

(Total 6 marks)

37 The diagrams represent the electronic structure of a magnesium atom and a chlorine atom.



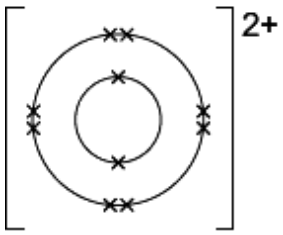
Magnesium atom



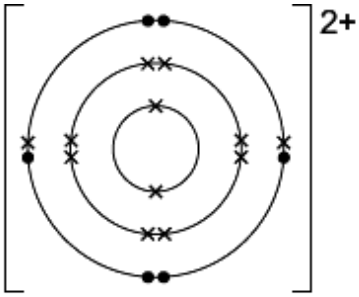
Chlorine atom

Magnesium reacts with chlorine to make the ionic compound called magnesium chloride. This contains magnesium ions, Mg^{2+}, and chloride ions, Cl^-

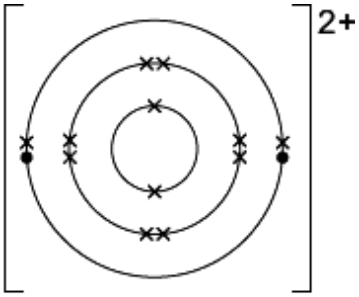
(a) (i) Which structure, **A**, **B** or **C**, represents a magnesium ion?



Structure **A**



Structure **B**

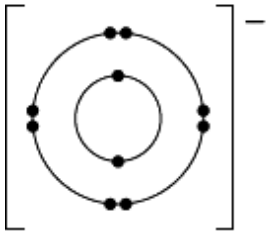


Structure **C**

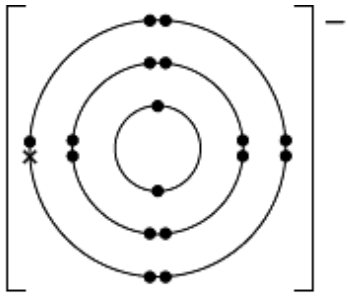
The magnesium ion is Structure ☐

(1)

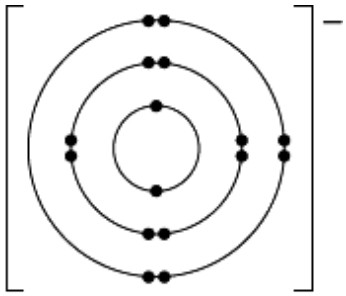
(ii) Which structure, **D**, **E** or **F**, represents a chloride ion?



Structure **D**



Structure **E**



Structure **F**

The chloride ion is Structure ☐

(1)

(b) Magnesium metal can be extracted from sea water.
Sea water contains magnesium chloride, $MgCl_2$

(i) Calcium hydroxide, $Ca(OH)_2$, is added to the sea water.
Magnesium hydroxide, $Mg(OH)_2$, is produced as a solid.

This is the equation for the reaction:

$$MgCl_2(aq) + Ca(OH)_2(aq) \rightarrow Mg(OH)_2(s) + CaCl_2(aq)$$

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

Magnesium hydroxide forms as a solid because it is [soluble / insoluble / dissolved] in water.

This type of reaction is called [precipitation. / neutralisation. / thermal decomposition.]

(2)

(ii) How is the solid magnesium hydroxide separated from the solution?

.....

(1)

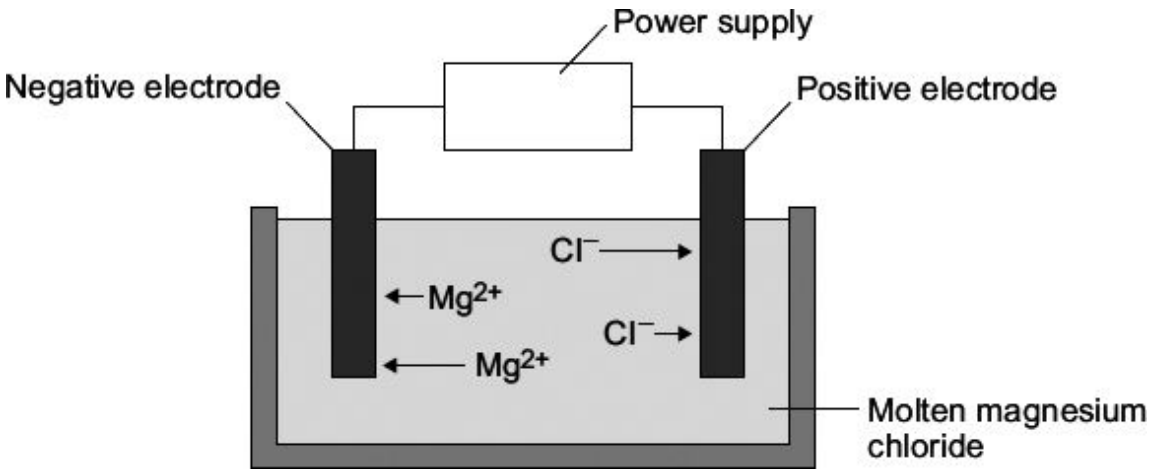
(iii) An acid is then added to the solid magnesium hydroxide to make magnesium chloride.

Draw a ring around the name of this acid.

nitric acid **hydrochloric acid** **sulfuric acid**

(1)

(c) Electrolysis is used to extract magnesium metal from magnesium chloride.



(i) What must be done to solid magnesium chloride to allow it to conduct electricity?

.....

(1)

(ii) Why do the magnesium ions move to the negative electrode?

.....

.....

(1)

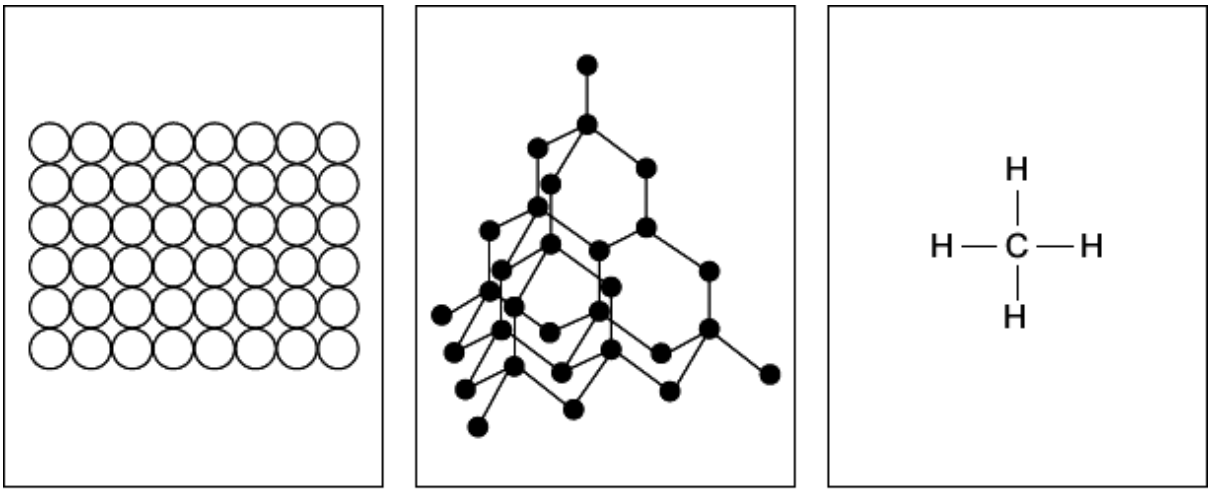
(iii) Name the product formed at the positive electrode.

.....

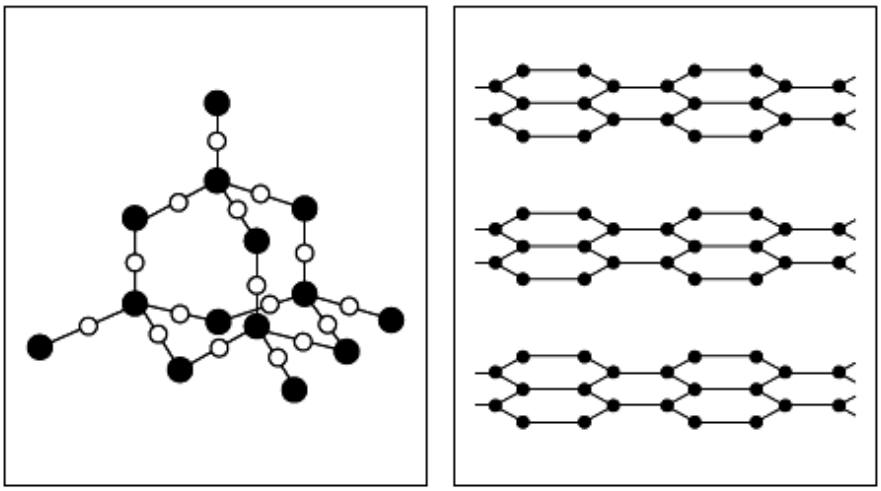
(1)

(Total 9 marks)

38 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)

39 (a) The symbol equation for the decomposition of hydrogen peroxide is:

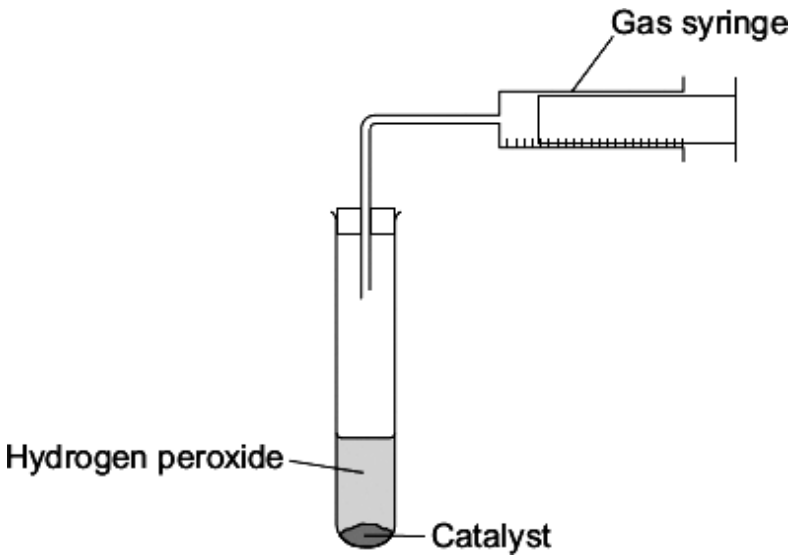
$$2H_2O_2 \rightarrow 2H_2O + O_2$$

Complete the word equation for the decomposition of hydrogen peroxide.

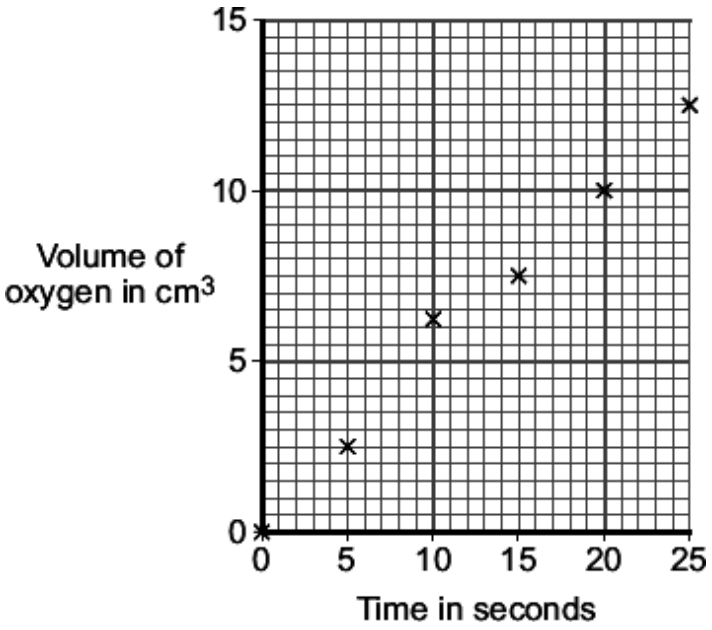
Hydrogen peroxide → ..... + ...

(1)

(b) A student did an experiment to see how quickly hydrogen peroxide decomposes.
The student used the apparatus shown below to measure the volume of oxygen.



(i) Draw a straight line of best fit to complete the graph.



(1)

(ii) Draw a circle around the anomalous point on the graph.

(1)

(iii) What is the volume of oxygen given off after 15 seconds?

..... cm^3

(1)

(iv) How did the volume of oxygen change between 0 and 25 seconds?

.....

(1)

(c) The student wanted to make the reaction faster.

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

(i) To make the reaction faster, the temperature should be

higher.

lower.

the same.

(1)

(ii) To make the reaction faster, the hydrogen peroxide should be

more dilute.

more concentrated.

the same.

(1)

(d) The diagram represents the bonding in oxygen.

O=O

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

(i) When two oxygen atoms bond, the atoms [share / transfer / delocalise] electrons.

(1)

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

(1)

(iii) Oxygen is made of [simple molecules. / a giant lattice. / macromolecules.]

(1)

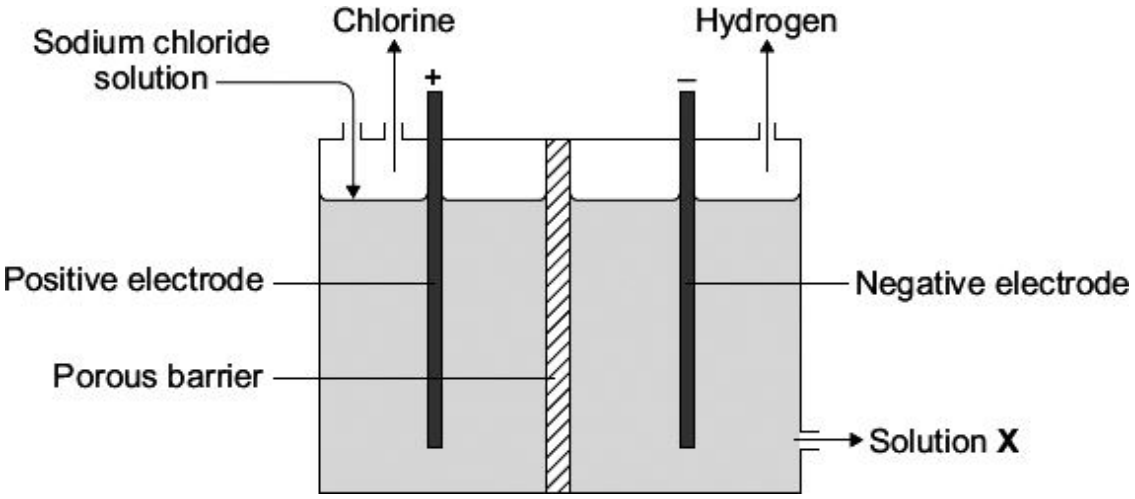
(e) When hydrogen peroxide decomposes water is produced.
Which **two** statements in the table explain why water is a liquid at room temperature?

Tick (✓) the **two** statements.

Statement	Tick (✓)
Water has a boiling point of 100 °C.	
Water is made of ions.	
Water has a melting point lower than room temperature.	
Water has a giant covalent structure.	

(2)
(Total 12 marks)

40 The electrolysis of sodium chloride solution is an industrial process.



(a) Why do chloride ions move to the positive electrode?

.....

(1)

(b) Sodium chloride solution contains two types of positive ions, sodium ions (Na^+) and hydrogen ions (H^+).

Tick (✓) the reason why hydrogen is produced at the negative electrode and **not** sodium.

Reason	Tick (✓)
Hydrogen is a gas.	
Hydrogen is less reactive than sodium.	
Hydrogen is a non-metal.	
Hydrogen ions travel faster than sodium ions.	

(1)

(c) Solution **X** is alkaline.

Which ion makes solution **X** alkaline?

.....

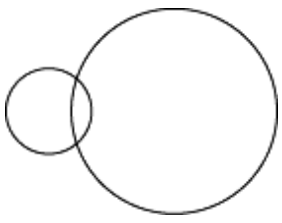
(1)

(d) Electrolysis of sodium chloride solution produces hydrogen and chlorine.
The hydrogen and chlorine can be used to make hydrogen chloride.

(i) The diagrams show how the outer electrons are arranged in atoms of hydrogen and chlorine.

Hydrogen atom Chlorine atom

Complete the diagram to show how the electrons are arranged in a molecule of hydrogen chloride (HCl).



(1)

(ii) Name the type of bond between the hydrogen and the chlorine atoms in a molecule of hydrogen chloride.

.....

(1)

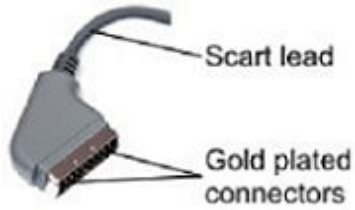
(iii) Some hydrogen chloride was bubbled into water. This made a solution with a pH of 1.

Which ion gave the solution a pH of 1?

.....

(1)
(Total 6 marks)

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



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

The connectors on this scart lead are coated with gold.

(a) Gold is a typical metal.

(i) Describe the structure and bonding of gold.

.....

.....

.....

.....

.....

.....

.....

.....

(3)

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

.....

.....

(1)

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

Suggest why this reduces the electrical conductivity of the metal.

.....

.....

.....

.....

(2)
(Total 6 marks)

42 The picture shows a wooden bowl.
The pieces of wood used for this bowl were dyed different colours.

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

The artist who made the bowl explained why he dissolved the coloured dyes in methanol.

I use different coloured dyes dissolved in methanol. I use methanol because with dyes dissolved in water the wood needs to be soaked for a longer time. The bowl dries more quickly if I use methanol instead of water.

(a) The artist uses methanol instead of water.

Give **two** reasons why.

1 .....

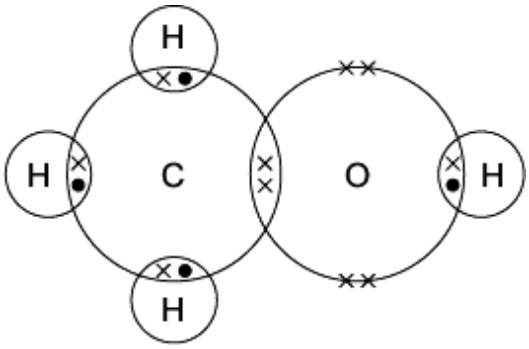
.....

2 .....

.....

(2)

(b) The diagram shows how the atoms are bonded in methanol.



Draw a ring around:

(i) the formula of methanol

CH_4O **CH^4O** **CHO_4**

(1)

(ii) the type of bonding in methanol.

covalent **ionic** **metallic**

(1)

(c) Methanol has a low boiling point.

Tick (✓) the reason why.

Reason why	Tick (✓)
It has a giant covalent structure.	
It is made of small molecules.	
It has a giant metallic structure.	

(1)
(Total 5 marks)

43 Welding blankets are placed under metals being welded. They protect the area under the welding from hot sparks or molten metal.

Some welding blankets are made from silicon dioxide.

(a) The table lists some properties of materials.

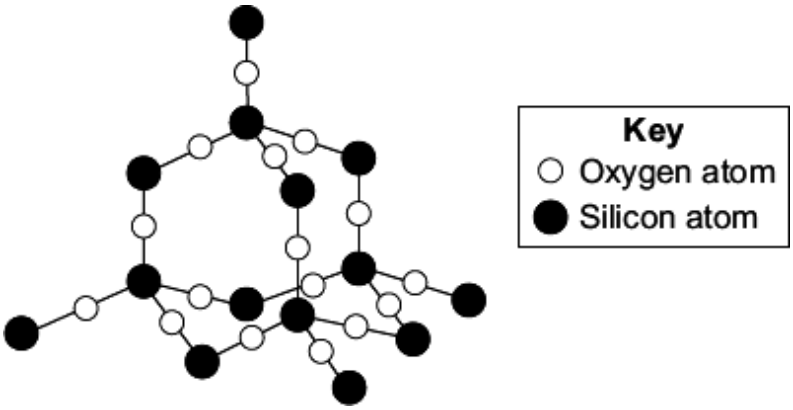
Two of these are properties of materials used to make welding blankets.

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

Property	Tick (✓)
High melting point	
Reacts with sparks	
Not flammable	
Low boiling point	

(2)

(b) Silicon dioxide has a giant structure. The diagram shows a small part of this structure.



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

(i) Silicon dioxide has a high melting point because [a few / some / all] of the atoms are joined to other atoms.

(1)

(ii) Each oxygen atom is joined to [two / three / four] silicon atoms.

(1)

(iii) The bonds between the atoms are [covalent. / ionic. / metallic.]

(1)

(iv) These bonds are [easily broken. / very strong. / weak.]

(1)

(Total 6 marks)

44 Calamine lotion is used to treat itching. The main ingredients are two metal oxides.

(a) One of the metal oxides has a relative formula mass (M_r) of 81.

The formula of this metal oxide is MO.
(M is **not** the correct symbol for the metal.)

The relative atomic mass (A_r) of oxygen is 16.

(i) Calculate the relative atomic mass (A_r) of metal M.

.....

.....

.....

Relative atomic mass (A_r) = ...

(2)

(ii) Use your answer to part (a)(i) and the periodic table on the Data Sheet to name metal M.

The name of metal M is ..... .

(1)

(b) The other metal oxide is iron(III) oxide.

This contains iron(III) ions (Fe^{3+}) and oxide ions (O^{2-}).

(i) Explain in terms of electrons how an iron atom (Fe) can change into an iron(III) ion (Fe^{3+}).

.....

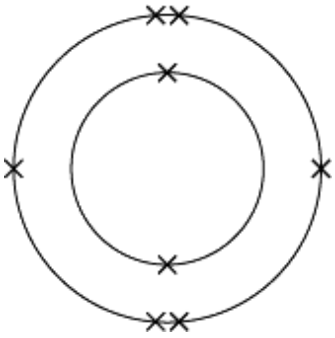
.....

.....

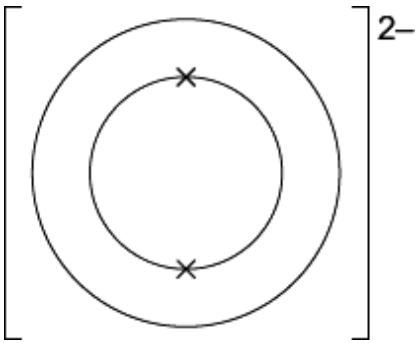
.....

(2)

(ii) The diagram below represents the electronic structure of an oxygen atom (O).

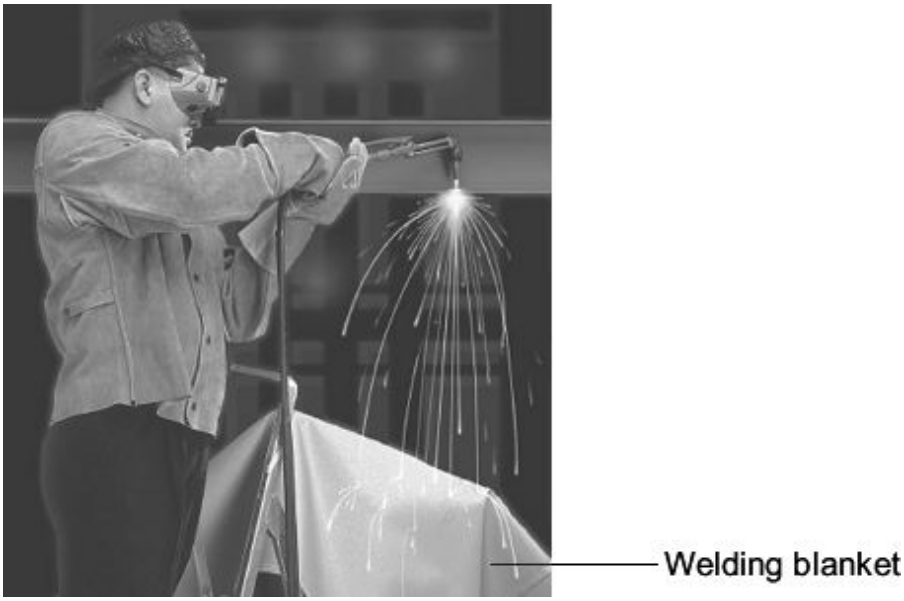


Complete the diagram below to show the electronic structure of an oxide ion (O^{2-}).



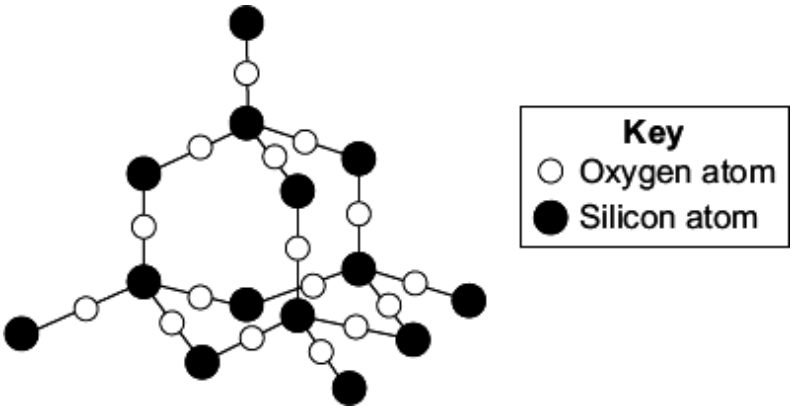
(1)
(Total 6 marks)

45 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.

.....

.....

.....

.....

.....

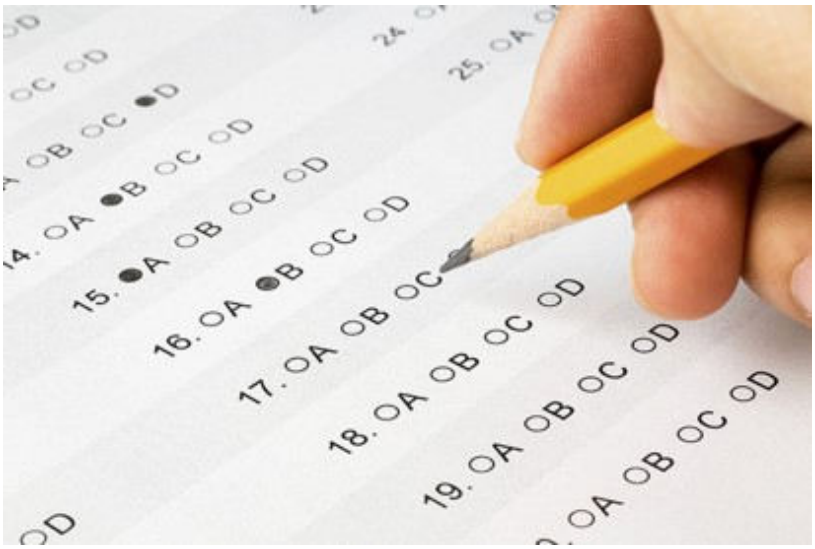
.....

.....

.....

(3)
(Total 3 marks)

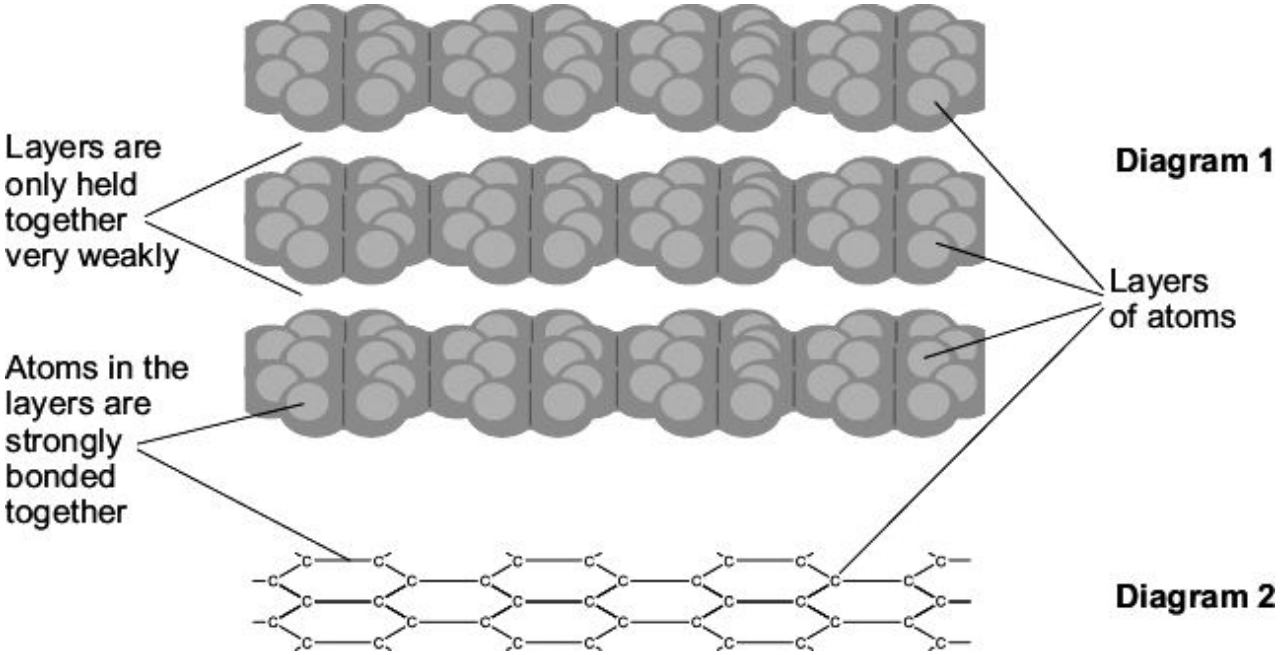
46 The picture shows a student using a pencil to complete a multiple choice answer sheet.



By albertogp123 [CC BY 2.0] , via Flickr

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)

47 Read the information in the box.

Flash powder is used to produce special effects at pop concerts.

Flash powder contains aluminium. The powder burns with a bright white flame and gives out lots of heat and light. It also produces white smoke.

The flash powder is placed on stage in a special container. At the bottom of the container there is a thin piece of wire. When the flash is needed, electricity is passed through the wire. The wire gets hot and starts the aluminium burning.

By russelljsmith [CC BY 2.0], via Flickr

(a) When aluminium burns the reaction is exothermic.

Give **one** piece of information from the box which shows that the reaction is exothermic.

.....

(1)

(b) The hot wire provides energy to start the aluminium burning.

Draw a ring around the name given to the energy needed to start a chemical reaction.

activation energy **potential energy** **solar energy**

(1)

(c) When aluminium burns it reacts with oxygen to make aluminium oxide.

Complete the word equation for this reaction.

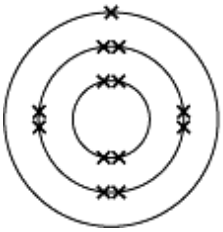
aluminium + ... → .....

(1)

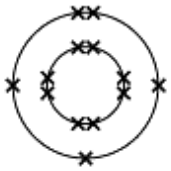
(d) An aluminium atom has 13 electrons.

Which diagram, **A**, **B** or **C**, represents the electronic structure of an aluminium atom?

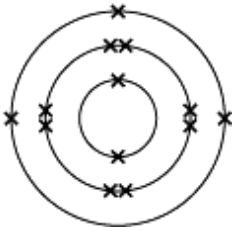
A



B



C



The electronic structure of an aluminium atom is diagram ☐

(1)

(e) The white smoke produced is aluminium oxide.

Aluminium oxide contains aluminium ions (Al^{3+}) and oxide ions (O^{2-}).

Draw a ring around the correct word in each box to complete each sentence.

(i) Electrons have [a negative / no / a positive] charge.

(1)

(ii) When an aluminium atom (Al) turns into an aluminium ion (Al^{3+})

it [gains / loses / shares] three electrons.

(1)

(iii) When an oxygen atom (O) turns into an oxide ion (O^{2-})

it | gains / loses / shares | | one / two / three | electrons.

(2)
(Total 8 marks)

48 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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

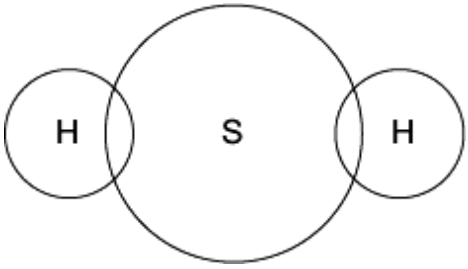
(4)

(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).

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

(1)
(Total 8 marks)

49 Hydrogen fluoride is used to make hydrofluoric acid.

(a) A company makes hydrogen fluoride by reacting solid calcium fluoride with sulfuric acid. The reaction takes place in a rotating kiln.

calcium fluoride + sulfuric acid → calcium sulfate + hydrogen fluoride

The company want this reaction to take place quickly.

(i) Rotating the kiln makes the reaction take place faster.

Suggest why.

.....

.....

(1)

(ii) Draw a ring around the correct word in each box.

To make the reaction take place **faster**:

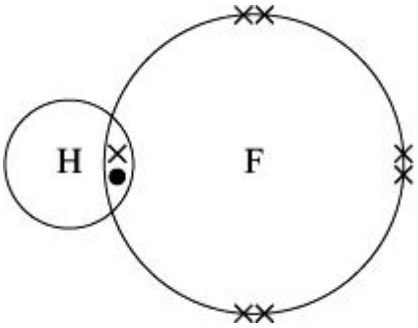
the temperature should be [higher / lower] so that the particles have [less / more] energy

the solid calcium fluoride should be [powder / lumps] to give a [small / big] surface area

the sulfuric acid solution should be [dilute / concentrated] to give [less / more] collisions between the particles each second.

(3)

(b) The diagram represents a molecule of hydrogen fluoride.



The hydrogen and fluorine atoms are joined by a covalent bond.

Use the correct word from the box to complete the sentence.

electrons	**neutrons**	**protons**

In a covalent bond the atoms share ..... .

(1)

(c) Hydrogen fluoride is dissolved in water to make an acidic solution of hydrofluoric acid.

Draw a ring around the symbol of the ion that makes the solution acidic.

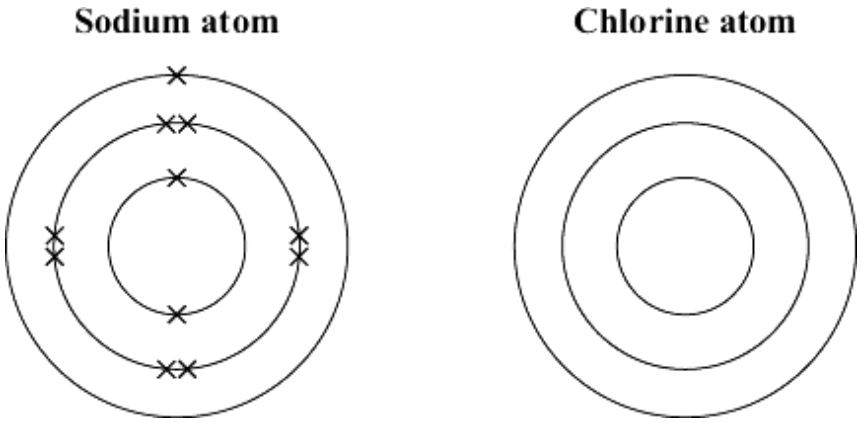
H^+ **OH^-** **F^-**

(1)
(Total 6 marks)

50 Sodium chloride is a raw material.

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

Complete the diagram for the electronic structure of a chlorine atom. A chlorine atom has 17 electrons.



(1)

(b) When sodium and chlorine react to form sodium chloride they form sodium ions (Na^+) and chloride ions (Cl^-).

How does a sodium atom change into a sodium ion?

.....

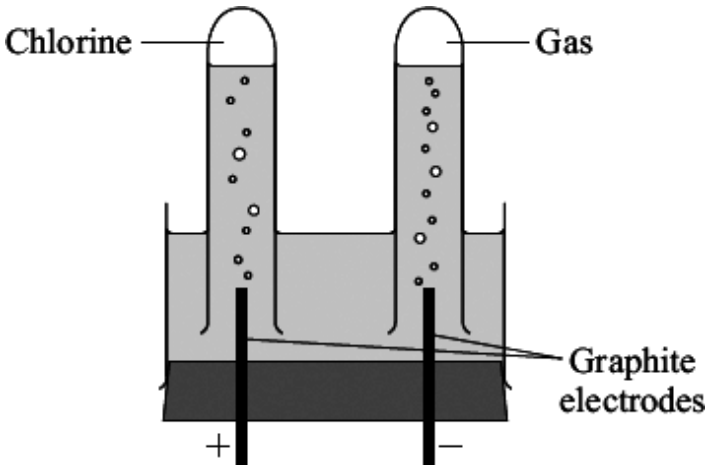
.....

.....

.....

(2)

(c) The diagram shows apparatus used in a school laboratory for the electrolysis of sodium chloride solution.



The solution contains sodium ions (Na^+), chloride ions (Cl^-), hydrogen ions (H^+) and hydroxide ions (OH^-).

(i) Why do chloride ions move to the positive electrode?

.....

(1)

(ii) Name the gas formed at the negative electrode.

.....

(1)

(d) Chlorine and chlorine compounds are used to bleach wood pulp that is used to make paper.

The article below is from a newspaper.

> Local people have been protesting outside a paper factory. They say:
> 'We want the company to stop using chlorine compounds. Chlorine compounds release poisons into the environment. The company should use safer compounds.'
>
> The company replied:
> 'Chlorine has been used safely for many years to treat drinking water. Only tiny amounts of chlorine are released, which cause no harm. Using other compounds will be more expensive and may put us out of business.'

(i) Why are some local people worried about the use of chlorine compounds?

.....

.....

(1)

(ii) Why might other local people want the company to continue to use chlorine compounds?

.....

.....

(1)

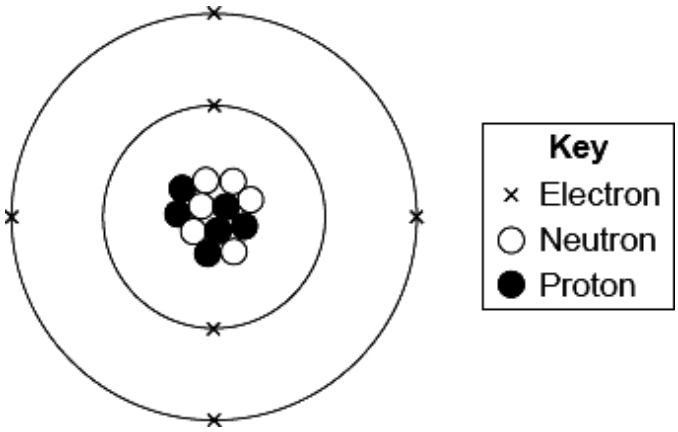
(iii) It is decided to have an inquiry.
Why should this be done by independent scientists?

.....

.....

(1)
(Total 8 marks)

51 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)

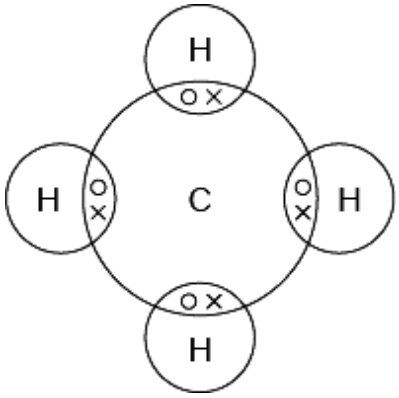
(c) A different carbon atom has 6 protons and 8 neutrons.

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)

52 This question is about lead iodide and magnesium iodide.

(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 solid.

lead ions in solution + iodide ions in solution → lead iodide solid

(i) Draw a ring around the name given to this type of reaction.

electrolysis **neutralisation** **precipitation**

(1)

(ii) Tick (✓) the method used to separate solid lead iodide from the solution.

Method	**Tick (✓)**
distillation	
evaporation	
filtration	

(1)

(iii) 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:

draw a ring around a soluble compound which contains lead ions

lead bromide **lead chloride** **lead nitrate**

draw a ring around a soluble compound which contains iodide ions.

lead iodide **silver iodide** **sodium iodide**

(2)

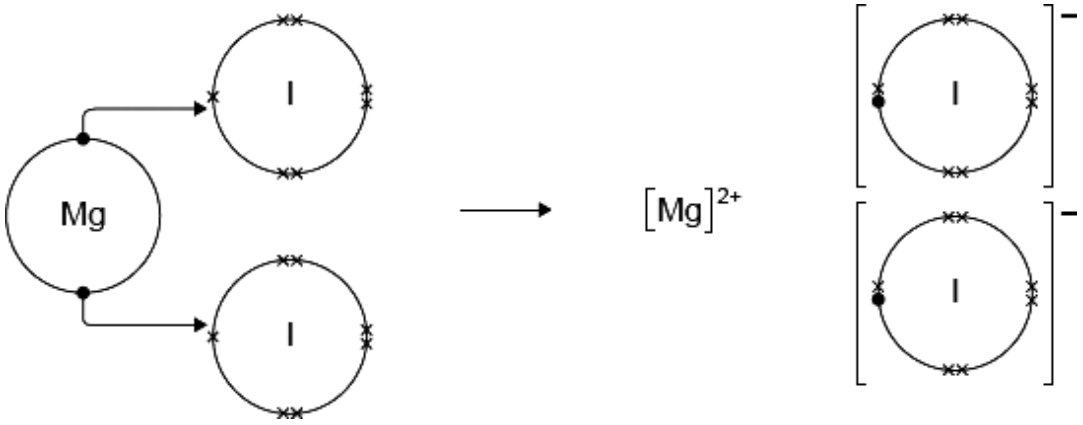
(b) Magnesium iodide can be made by reacting magnesium with iodine.

magnesium + iodine → magnesium iodide

The diagram shows how this takes place.

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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

(4)
(Total 8 marks)

53 This question is about some compounds of 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.

$$Pb^{2+}(aq) + 2I^{-}(aq) \rightarrow PbI_2(s)$$

(i) 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 name:

a soluble compound which contains lead ions .....

a soluble compound which contains iodide ions .....

(2)

(ii) Suggest a method of separating the lead iodide from the solution.

.....

(1)

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

$$Mg + I_2 \rightarrow MgI_2$$

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.

.....

.....

.....

.....

.....

.....

.....

.....

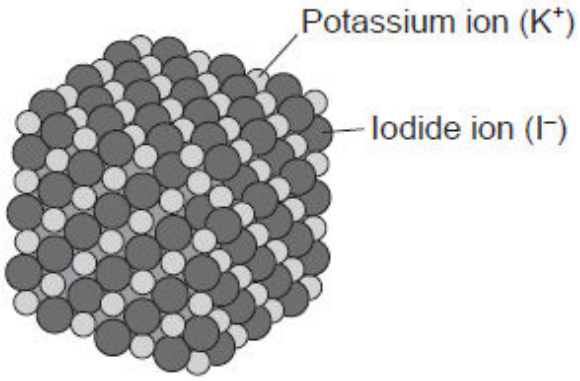
.....

.....

.....

(4)

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



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

.....

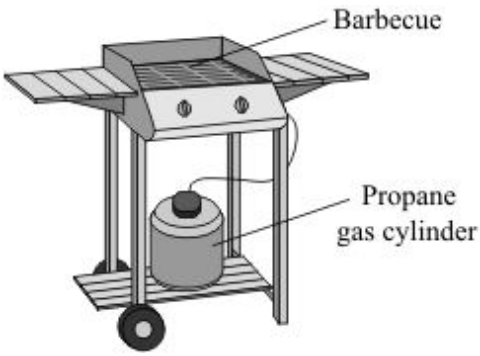
.....

.....

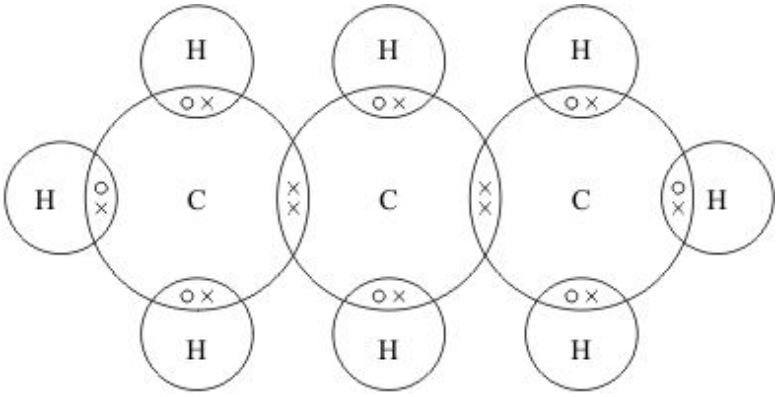
.....

(2)
(Total 9 marks)

54 This barbecue burns propane gas.



The diagram represents a propane molecule.



(a) What is the formula of propane? .....

(1)

(b) (i) Draw a ring around the name of the particle represented by the symbols ○ and × in the diagram.

electron **neutron** **proton**

(1)

(ii) Draw a ring around the type of bonding that holds the atoms together in a propane molecule.

covalent **ionic** **metallic**

(1)

(c) Under high pressure in the cylinder propane is a liquid.
Liquid propane evaporates easily to form a gas when the tap on the cylinder is opened.

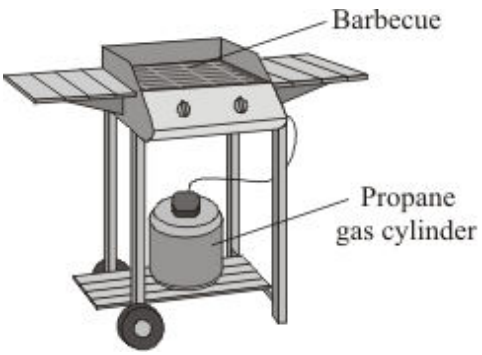
Draw a ring around the correct answer in each box to explain why propane evaporates easily.

Propane has a	high low	boiling point because it consists of	large small	molecules.

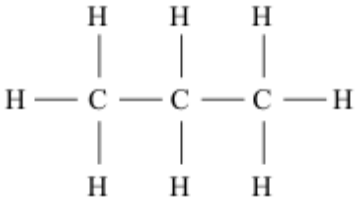
(1)

(Total 4 marks)

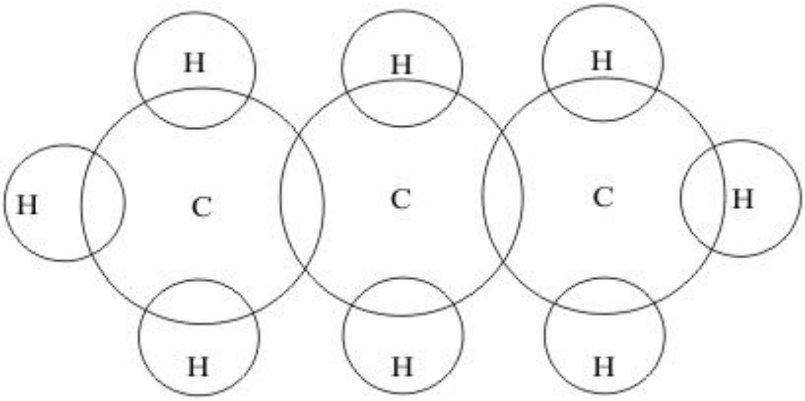
55 This barbecue burns propane gas.



The structure of propane is shown below.



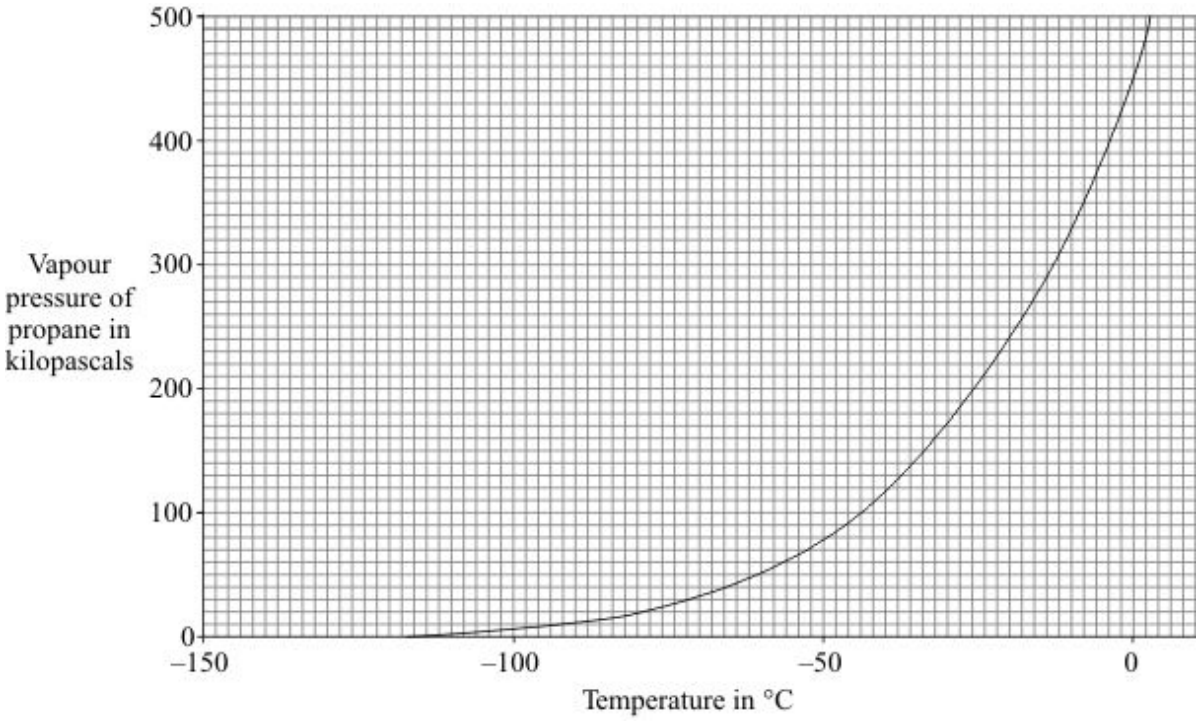
(a) Complete the diagram to show how the outer energy level (shell) electrons of hydrogen and carbon are arranged in a molecule of propane.



(1)

(b) The graph shows how the vapour pressure of propane changes with temperature.

The vapour pressure of a liquid is the pressure of the vapour above the liquid.



(i) Describe, as fully as you can, how the vapour pressure of propane changes with temperature.

.....

.....

.....

.....

.....

(2)

(ii) The boiling point of a liquid is the temperature at which its vapour pressure is equal to the air pressure above the liquid.

Use the graph to find the boiling point of propane when the air pressure is 100 kilopascals.

Boiling point ..... °C

(1)

(c) Explain, in terms of molecules, why propane has a low boiling point.

.....

.....

.....

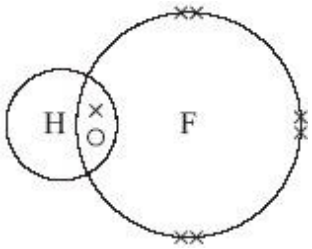
.....

.....

(2)
(Total 6 marks)

56 This question is about fluorine and some of its compounds.

(a) The diagram represents a molecule of hydrogen fluoride.



Draw a ring around the type of bonding that holds the hydrogen and fluorine atoms together in this molecule.

covalent **ionic** **metallic**

(1)

(b) Fluorine is made in industry by the electrolysis of a mixture of potassium fluoride and hydrogen fluoride.

(i) Use **one** word from the box to complete the sentence.

gas	**liquid**	**solid**

To allow electrolysis to take place the mixture of potassium fluoride and

hydrogen fluoride must be ..... .

(1)

(ii) The mixture of potassium fluoride and hydrogen fluoride contains fluoride ions (F^-), hydrogen ions (H^+) and potassium ions (K^+).

Use **one** word from the box to complete the sentence.

fluorine	**hydrogen**	**potassium**

During electrolysis the element formed at the **positive** electrode is

..... .

(1)

(c) Fluoride ions are sometimes added to drinking water. It is thought that these ions help to reduce tooth decay.

(i) Tick (✓) **one** question that **cannot** be answered by scientific investigation alone.

Question	**Tick (✓)**
Do fluoride ions in drinking water reduce tooth decay?	
Are fluoride ions in drinking water harmful to health?	
Should fluoride ions be added to drinking water?	

(1)

(ii) Explain why you have chosen this question.

.....

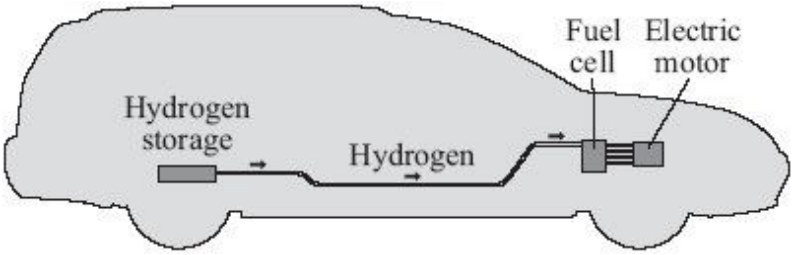
.....

(1)

(Total 5 marks)

57 Read the article and then answer the questions that follow.

Hydrogen fuel for cars?



Hydrogen is an excellent fuel. It can be made by the electrolysis of potassium hydroxide solution.

Hydrogen gas can be stored under pressure in a cylinder but a leak of the gas could cause an explosion.

It has been found that lithium nitride can absorb and then release large volumes of hydrogen. A chemical reaction takes place between the hydrogen and the lithium nitride. The hydrogen is held in the resulting compounds by chemical bonds.

The problem is that the rate at which hydrogen is absorbed and then released from normal sized particles of lithium nitride is slow.

Recently scientists have made 'nanosized' particles of lithium nitride. These particles absorb hydrogen in the same way as normal sized lithium nitride particles. The 'nanosized' particles have the advantage that they absorb and release the hydrogen much faster when needed in the fuel cell.

It is hoped that 'nanosized' particles of lithium nitride may provide a safe method of storing hydrogen in the future.

(a) Hydrogen is produced at the negative electrode during the electrolysis of potassium hydroxide solution.

(i) Why are hydrogen ions attracted to the negative electrode?

.....

.....

.....

(1)

(ii) Potassium ions are also attracted to the negative electrode.

Explain why hydrogen gas is formed but not potassium.

.....

.....

.....

(1)

(b) Lithium nitride is made by reacting lithium with nitrogen.

Balance the equation for this reaction.

..... $Li + N_2 \rightarrow$ ..... Li_3N

(1)

(c) (i) The equation for the reaction of lithium nitride with hydrogen is:

$$Li_3N + 2H_2 \rightleftharpoons LiNH_2 + 2LiH$$

What feature of this reaction allows the hydrogen to be released?

.....

.....

(1)

(ii) Hydrogen stored in a fuel tank filled with lithium nitride would be safer in an accident than a cylinder full of hydrogen.

Suggest and explain why.

.....

.....

.....

.....

.....

(2)

(d) Lithium nitride is an ionic compound which contains lithium ions (Li^+) and nitride ions (N^{3-}).

(i) The formation of a lithium ion from a lithium atom is an oxidation reaction.

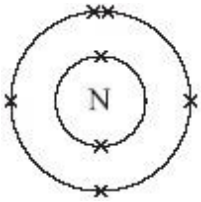
Explain why.

.....

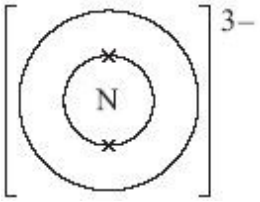
.....

(1)

(ii) The diagram shows the electronic structure of a nitrogen atom.

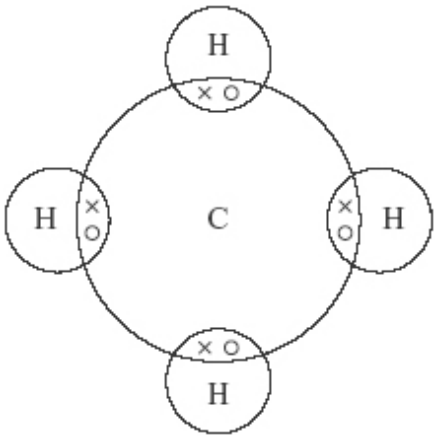


Complete the diagram below to show the electronic structure of a nitride ion (N^{3-}).



(1)
(Total 8 marks)

58 The diagram represents a particle of methane.



(a) What is the formula of methane? .....

(1)

(b) Choose a word from the box to answer the question.

atom	**ion**	**molecule**

Which of the words best describes the methane particle shown in the diagram?

.....

(1)

(c) Choose a word from the box to answer the question.

covalent	ionic	metallic

What is the type of bonding shown in the diagram?

.....

(1)
(Total 3 marks)