1 Hydrogen chloride is formed in the reaction between hydrogen and chlorine.
The equation for the reaction is

$$H_2 + Cl_2 \rightarrow 2HCl$$

(a) Each molecule in this equation contains the same type of bonding.

Name this type of bonding.

(1)

covalent

(b) The bonding in a hydrogen molecule is strong.

Explain why the boiling point of hydrogen is low.

(2)

the intermoleculat bonds are weak and so require little energy to separate the H2 molecules.

(c) Explain how the two atoms in a chlorine molecule are held together.

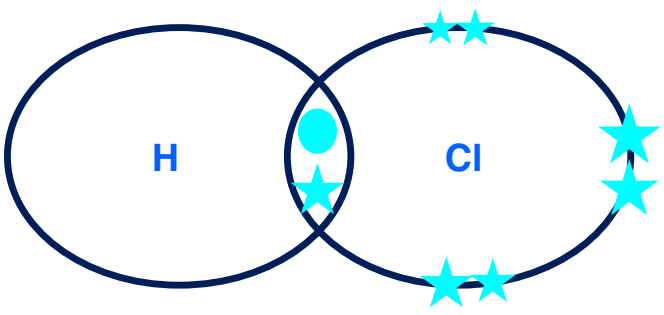
(2)

Each Cl atom shares an electron with the other forming a covalent bond which binds them together.

(d) Draw a dot and cross diagram to show the bonding in a hydrogen chloride molecule.

Show only the outer electrons in each atom.

(2)



(e) Hydrogen chloride gas dissolves in water to form solution A.

Hydrogen chloride gas dissolves in methylbenzene to form solution B.

A teacher adds a piece of magnesium ribbon to each solution.

Explain why she observes effervescence with solution A but not with solution B.

(3)

HCl dissolves to form hydrochloric acid. Magnesium reacts with the acid to give off H gas. Solution b is not acidic and so does not contain H+ ions to form bubbles.

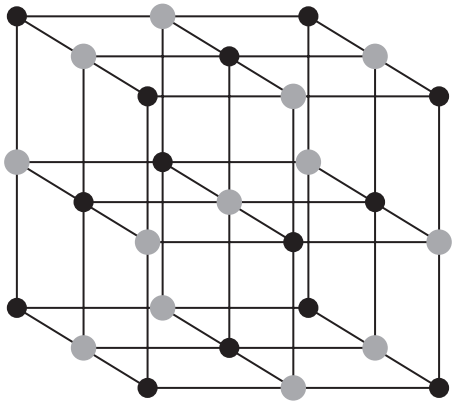
(Total for Question 1 = 10 marks)

2 Sodium chloride (NaCl) and silicon dioxide (SiO_2) both have giant lattice structures.

Sodium chloride is an ionic compound.

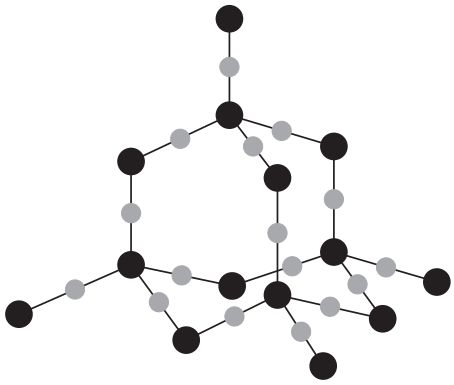
Silicon dioxide is a covalent compound.

Structure of sodium chloride



● Na^+ ● Cl^-

Structure of silicon dioxide



● Si ● O

The table shows some properties of each compound.

Sodium chloride	Silicon dioxide
melting point = 801 °C	melting point = 1610 °C
soluble in water	insoluble in water
conducts electricity when molten	does not conduct electricity when molten

(a) (i) Explain why silicon dioxide has a high melting point.

(2)

covalent bonds need to be broken, these are strong so a large amount of energy is needed.

(ii) Suggest why the melting point of silicon dioxide is higher than the melting point of sodium chloride.

(1)

The covalent bonds in silicon dioxide are stronger than the ionic bonds in sodium chloride.

(b) State why sodium chloride conducts electricity when molten.

(1)

Ions are free to move when sodium chloride is molten.

(c) Carbon dioxide is described as a simple molecular substance.

State why carbon dioxide (CO_2) is a gas at room temperature.

(1)

The intermolecular forces are weak and so only a small amount of energy is needed to separate the molecules.

(Total for Question 2 = 5 marks)

6 Molybdenum (Mo) is a metal. It is often used to make an alloy with iron.

Like iron, it is extracted from its oxide. Unlike iron, it occurs mainly as its sulfide.

(a) Molybdenum sulfide is converted into molybdenum oxide by heating in air.
The equation for this reaction is

$$2MoS_2 + 7O_2 \rightarrow 2MoO_3 + 4SO_2$$

(i) Why is molybdenum said to be oxidised in this reaction?

(1)

Because it gains Oxygen.

(ii) The sulfur dioxide formed in the reaction could form acid rain if it escaped into the atmosphere.

Write a chemical equation for the formation of an acid from sulfur dioxide.

(1)

SO2 + H2O --> H2 SO3

(b) The table shows the melting points of molybdenum oxide and sulfur dioxide.

	Melting point in °C
molybdenum oxide	800
sulfur dioxide	–75

The melting point indicates the type of bonding and structure in a compound.

(i) What is the type of bonding in a molecule of sulfur dioxide?

(1)

covalent

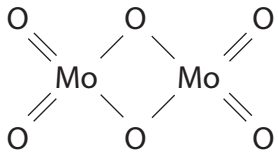
(ii) Explain why the melting point of sulfur dioxide is low.

(2)

the intermolecular forces are weak so only a little energy is needed of overcome them.

(iii) The melting point of molybdenum oxide suggests that it has ionic bonding. However, it is often represented as a molecular structure.

Deduce the molecular formula of molybdenum oxide as shown in this structure.



(1)

Mo2 O6

(c) The metallic structure of molybdenum gives it some typical properties.

(i) Describe the metallic structure of molybdenum.

(2)

Molybdenum ions are arranged in a regular lattice amongst a sea of delocalised free electrons.

(ii) Explain why molybdenum is a good conductor of electricity.

(2)

the free electrons can move through the material allowing it to conduct.

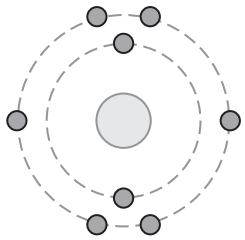
(iii) Explain why molybdenum is malleable.

(2)

the molybdenum atoms are able to slip past each other and remain in their new positions.

(Total for Question 6 = 12 marks)

7 The diagram shows how the electrons are arranged in an atom of oxygen.

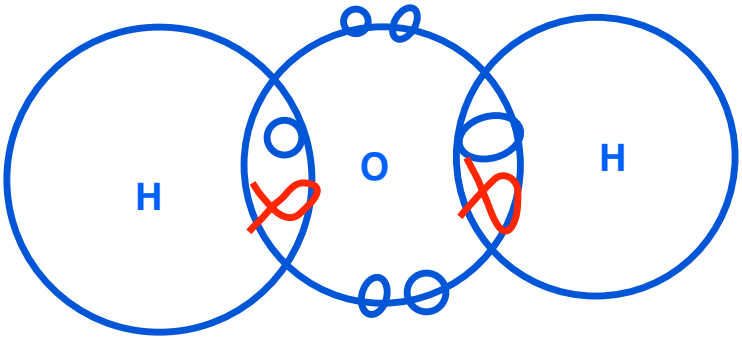


Oxygen atoms form both covalent and ionic bonds.

(a) Water is formed when two atoms of hydrogen combine with one atom of oxygen.

(i) Draw a dot and cross diagram of a molecule of water. You need only show the electrons in the outer shells.

(2)



(ii) Explain how the covalent bonds in the water molecule hold the hydrogen and oxygen atoms together.

(2)

There is a strong force of electrostatic attraction between the shared pairs of electrons and the nuclei of Hydrogen and Oxygen.

(b) The electronic configuration of a sodium atom is 2.8.1
Sodium oxide, Na_2O, is an ionic compound formed when sodium reacts with oxygen.

(i) Describe, in terms of electrons, what happens when sodium oxide is formed in this reaction.

(3)

Sodium has 1 outer shell electron and Oxygen has 6 so for them to each complete their outer shells two Sodium atoms will each lose 1 electron and give it to the Oxygen atom. The Oxygen atom, having gained 2 electrons now has a full outer shell and the Sodiums now had just 2 electrons in their remaining shell.

(ii) The reaction of sodium to form sodium oxide can be described as oxidation because it involves the addition of oxygen.

State one other reason why this reaction can be described as oxidation.

(1)

It loses electrons

(c) Explain why water has a much lower melting point than sodium oxide.

(2)

the attractive forces between water molecules are weaker than those in sodium oxide and so need less energy to break.

(d) A teacher added sodium oxide to water in a beaker.
The equation shows the reaction that occurred.

$$Na_2O(\text{s}) + H_2O(\text{l}) \rightarrow 2NaOH(\text{aq})$$

(i) Insert the appropriate state symbols in this equation.

(2)

(ii) Some universal indicator was then added to the beaker. A colour change occurred. State the final colour of the universal indicator and identify the ion responsible for the colour change.

(2)

Final colour **blue or purple**

Ion responsible for colour change **OH- (hydroxide)**

(Total for Question 7 = 14 marks)