Q1.

This question is about carbon and its compounds.

Fullerenes are molecules of carbon atoms.

The first fullerene to be discovered was Buckminsterfullerene (C_{60}).

(a) What shape is a Buckminsterfullerene molecule?

_____

(1)

(b) Give **one** use of a fullerene.

_____

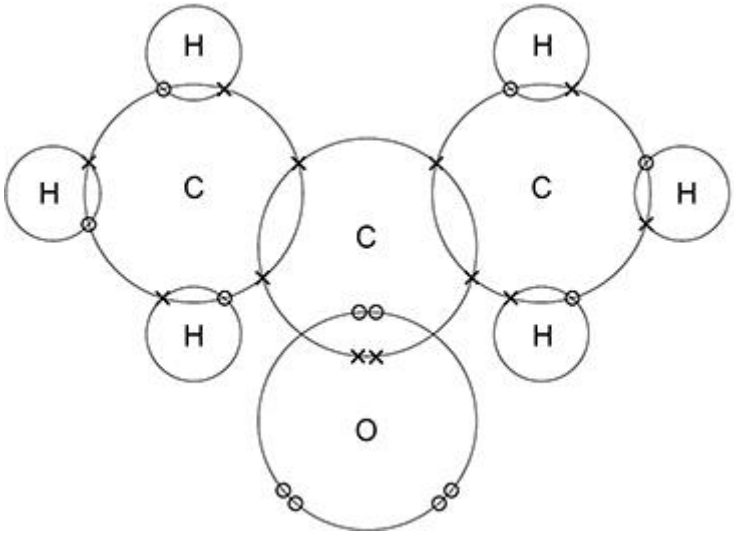
_____

(1)

Propanone is a compound of carbon, hydrogen and oxygen.

Figure 1 shows the dot and cross for a propanone molecule.

Figure 1

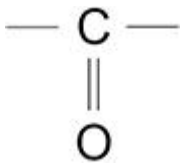


(c) Complete **Figure 2** to show a propanone molecule.

Use a line to represent each single bond.

Use **Figure 1**.

Figure 2



(1)

(d) Determine the molecular formula of propanone.

Use **Figure 1**.

Molecular formula = _____

(1)

(e) Propanone is a liquid with a low boiling point.

Why does propanone have a low boiling point?

Tick (✓) **one** box.

The covalent bonds are strong. ☐

The covalent bonds are weak. ☐

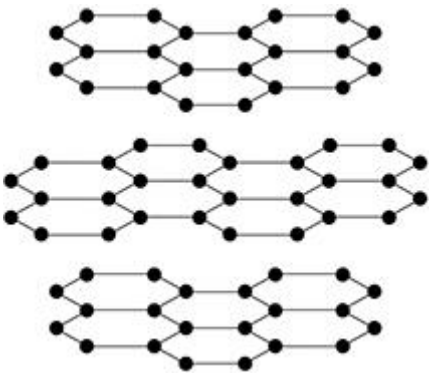
The intermolecular forces are strong. ☐

The intermolecular forces are weak. ☐

(1)

(f) **Figure 3** represents the structure of graphite.

Figure 3



Explain why graphite is:

- a good electrical conductor
- soft and slippery.

You should answer in terms of structure and bonding.

(6)

(Total 11 marks)

Q2.

This question is about Group 1 elements.

(a) Give **two** observations you could make when a small piece of potassium is added to water.

1 _____

2 _____

(2)

(b) Complete the equation for the reaction of potassium with water.

You should balance the equation.

$$K + H_2O \rightarrow \quad +$$

(2)

(c) Explain why the reactivity of elements changes going down Group 1.

(4)

Sodium reacts with oxygen to produce the ionic compound sodium oxide.

Oxygen is a Group 6 element.

(d) Draw a dot and cross diagram to show what happens when atoms of sodium and oxygen react to produce sodium oxide.

Diagram

(4)

(e) Why is oxygen described as being reduced in the reaction between sodium and oxygen?

(1)

(f) Explain why sodium oxide has a high melting point.

_____

_____

_____

(3)

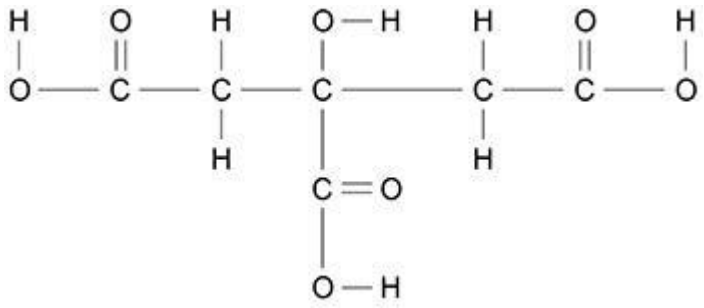
(Total 16 marks)

Q3.

This question is about citric acid.

Figure 1 represents one molecule of citric acid.

Figure 1



(a) Complete the molecular formula of citric acid.

Use **Figure 1**.

C_6H __ O __

(1)

(b) What type of bonding is shown in **Figure 1**?

Tick (✓) **one** box.

Covalent ☐

Ionic ☐

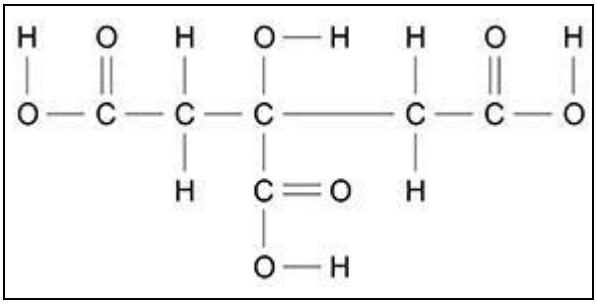
Metallic ☐

(1)

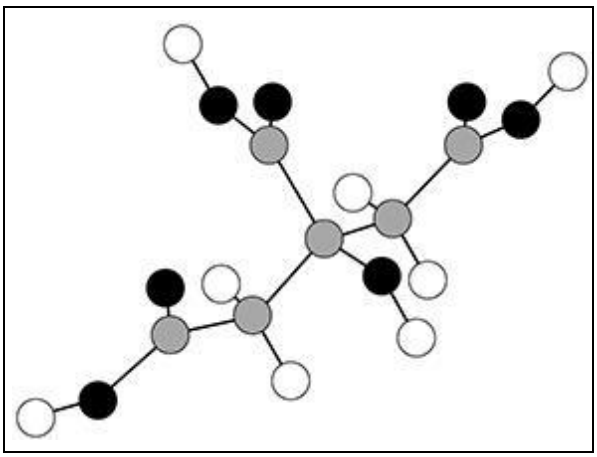
(c) **Figure 2** shows two representations of one molecule of citric acid, **A** and **B**.

Figure 2

A



B



Give **two** advantages of representation **A** compared with representation **B**.

Advantages of **A**:

1 _____

_____

2 _____

_____

_____

(2)

A student investigated the temperature change during the reaction between citric acid and sodium hydrogencarbonate solution.

Citric acid is a solid.

This is the method used.

1. Pour 25 cm^3 of sodium hydrogencarbonate solution into a polystyrene cup.
2. Measure the temperature of the sodium hydrogencarbonate solution.
3. Add 0.25 g of citric acid to the cup.
4. Stir the solution.
5. Measure the temperature of the solution.
6. Repeat steps 3 to 5 until a total of 2.00 g of citric acid has been added.

The table below shows some of the student's results.

Mass of citric acid added in g	Temperature of solution in °C
0.00	22.6
0.25	22.2
0.50	21.8
0.75	21.4
1.00	21.0
1.25	20.6

(d) How do the results in table above show that the reaction is endothermic?

_____

_____

(1)

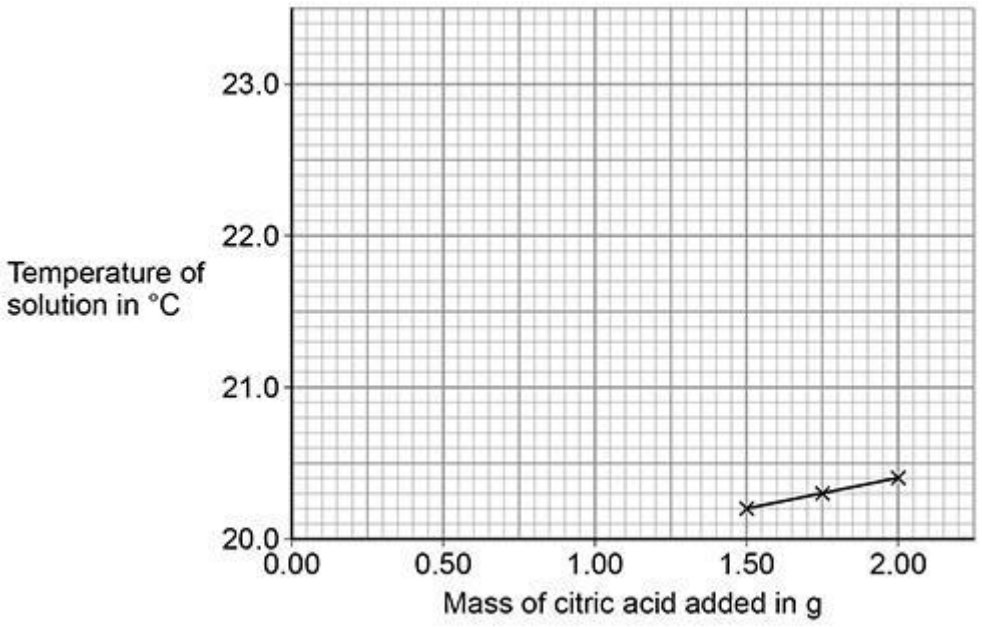
(e) Three of the student's results are plotted on the graph below.

A line of best fit for these points is drawn.

Complete the graph below.

You should:

- plot the data from table above on the graph below
- draw a line of best fit through the points you have plotted
- extend your line of best fit to meet the line of best fit already drawn on the graph below.



(4)

(f) Determine the overall temperature change for the reaction.

Use the graph above.

_____

_____

Overall temperature change = _____ °C

(2)

(g) What is the dependent variable in this investigation?

Tick (✓) **one** box.

Mass of citric acid	☐
Temperature of solution	☐
Volume of solution	☐

(1)

(Total 12 marks)

Q4.

This question is about structure and bonding.

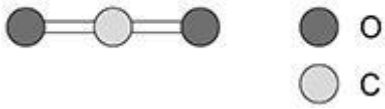
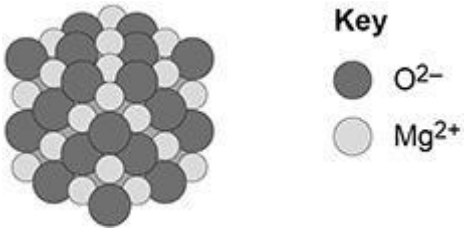
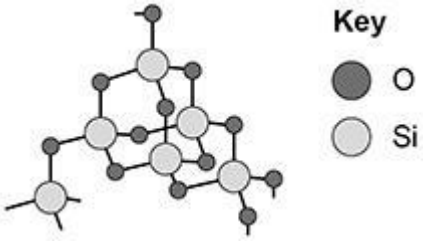
(a) Which **two** substances have intermolecular forces between particles?

Tick (✓) **two** boxes.

Diamond	☐
Magnesium	☐
Poly(ethene)	☐
Sodium chloride	☐
Water	☐

(2)

(b) The table below shows the structures of three compounds.

Compound	Structure
Carbon dioxide	
Magnesium oxide	
Silicon dioxide	

Compare the structure and bonding of the three compounds:

- carbon dioxide
- magnesium oxide
- silicon dioxide.

(6)

(Total 8 marks)

Q5.

This question is about compounds of oxygen and hydrogen.

Figure 1 represents the structure of hydrogen peroxide.

Figure 1

(a) What is the correct formula of hydrogen peroxide?

Tick (✓) **one** box.

- H2O2 ☐
- HO_2 ☐
- H^2O^2 ☐
- H_2O_2 ☐

(1)

(b) Which type of bonding is shown in **Figure 1**?

Tick (✓) **one** box.

- Covalent ☐
- Ionic ☐
- Metallic ☐

(1)

(c) Hydrogen peroxide decomposes in the presence of a catalyst.

Which elements are often used as catalysts?

Tick (✓) **one** box.

Alkali metals ☐

Halogens ☐

Transition metals ☐

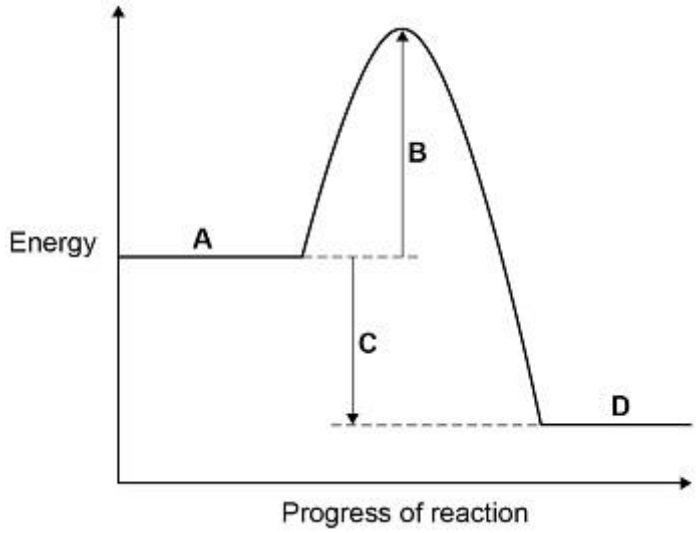
(1)

Figure 2 shows the reaction profile for the decomposition of hydrogen peroxide.

The word equation for this reaction is:

hydrogen peroxide → water + oxygen

Figure 2



Labels **A**, **B**, **C** and **D** each represent a different part of the reaction profile.

Use **Figure 2** to answer parts (d) and (e).

(d) Which label shows the activation energy?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(e) Which label shows the energy of hydrogen peroxide?

Tick (✓) **one** box.

A ☐ B ☐ C ☐ D ☐

(1)

(f) The decomposition of hydrogen peroxide gives out energy to the surroundings.

What type of reaction is this?

Tick (✓) **one** box.

Displacement ☐

Endothermic ☐

Exothermic ☐

Neutralisation ☐

(1)

(g) Hydrogen and oxygen form water.

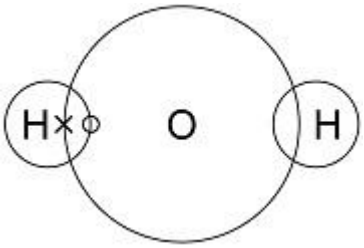
A hydrogen atom contains one electron.

An oxygen atom contains six electrons in the outer shell.

Complete **Figure 3** to show a dot and cross diagram for a water molecule.

Show the outer electrons only.

Figure 3



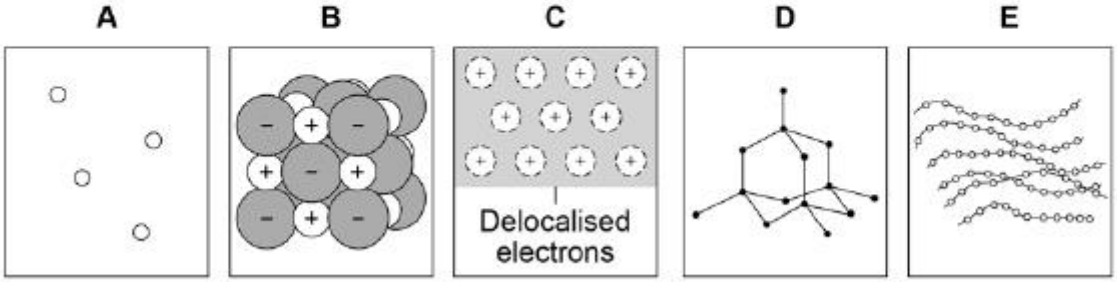
(2)

(Total 8 marks)

Q6.

Figure 1 shows the structure of five substances.

Figure 1



(a) Which diagram shows a gas?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐ **E** ☐

(1)

(b) Which diagram shows the structure of diamond?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐ **E** ☐

(1)

(c) Which diagram shows a metallic structure?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐ **E** ☐

(1)

(d) Which diagram shows a polymer?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐ **E** ☐

(1)

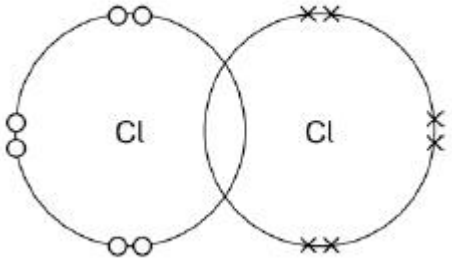
(e) A chlorine atom has 7 electrons in the outer shell.

Two chlorine atoms covalently bond to form a chlorine molecule, Cl_2

Figure 2 is a dot and cross diagram showing the outer shells and some electrons in a chlorine molecule.

Complete the dot and cross diagram.
Show only the electrons in the outer shell.

Figure 2



(1)

(f) What is the reason for chlorine's low boiling point?

Tick (✓) **one** box.

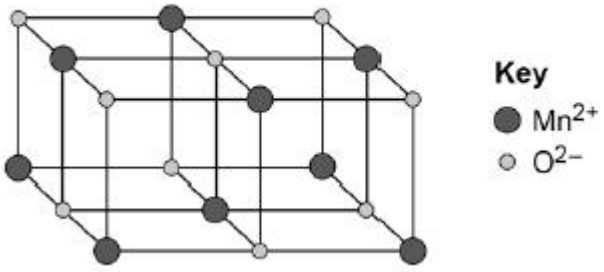
- Strong covalent bonds ☐
- Strong forces between molecules ☐
- Weak covalent bonds ☐
- Weak forces between molecules ☐

(1)

Figure 3 represents the structure of manganese oxide.

Manganese oxide is an ionic compound.

Figure 3



(g) Determine the empirical formula of manganese oxide.

Use **Figure 3**.

_____

_____

Empirical formula = _____

(1)

(h) Why does manganese oxide conduct electricity as a liquid?

Tick (✓) **one** box.

Atoms move around in the liquid	☐
Electrons move around in the liquid	☐
Ions move around in the liquid	☐
Molecules move around in the liquid	☐

(1)

(Total 8 marks)

Q7.

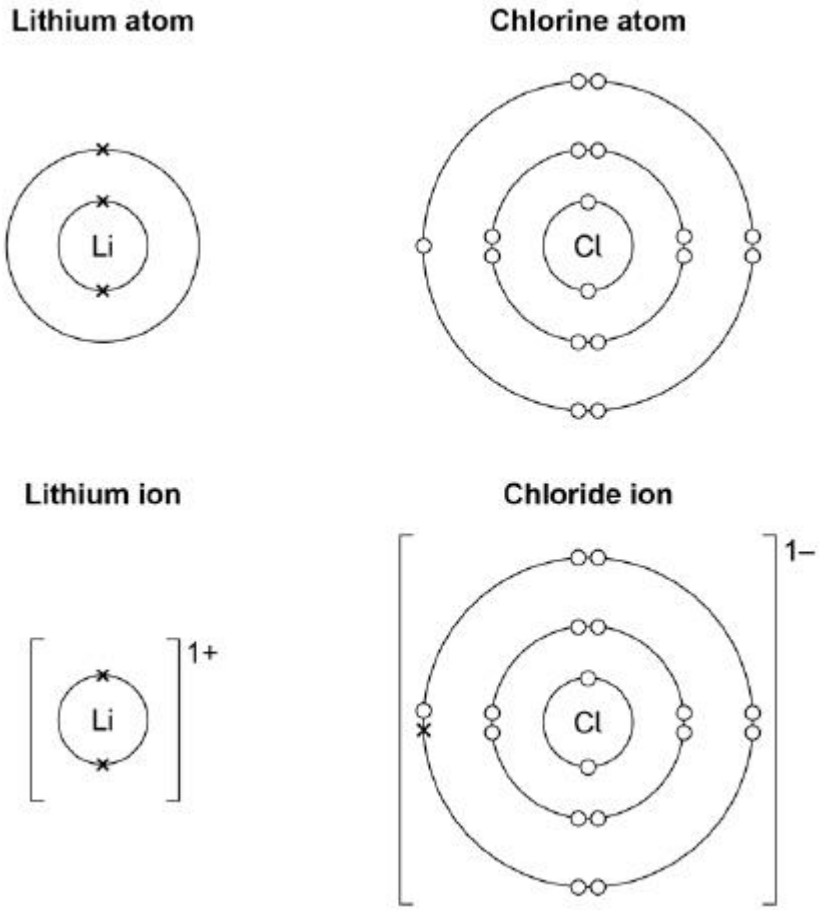
This question is about metal compounds.

(a) Lithium reacts with chlorine to produce lithium chloride.

When lithium atoms and chlorine atoms react to produce lithium chloride, lithium ions and chloride ions are formed.

The diagram shows the electronic structures of the atoms and ions.

The symbols **o** and **x** are used to represent electrons.



Describe what happens when a lithium atom reacts with a chlorine atom.

Answer in terms of electrons.

(4)

Zinc sulfate can be made by two methods.

The equations for the two methods are:

Method 1: $ZnO + H_2SO_4 \longrightarrow ZnSO_4 + H_2O$

Method 2: $ZnCO_3 + H_2SO_4 \longrightarrow ZnSO_4 + H_2O + CO_2$

(b) Calculate the percentage atom economy for making zinc sulfate in **Method 1**.

Use the equation:

percentage atom economy =

$$\frac{\text{relative formula mass of } ZnSO_4}{\text{relative formula mass of } ZnO + \text{relative formula mass of } H_2SO_4} \times 100$$

Give your answer to 3 significant figures.

Relative formula masses (M_r): ZnO = 81 H_2SO_4 = 98 $ZnSO_4$ = 161

_____

_____

_____

_____

_____

Percentage atom economy = _____ %

(3)

(c) **Method 1** gives a higher percentage atom economy for making zinc sulfate than **Method 2**.

Give a reason why it is important to use a reaction with a high atom economy.

_____

_____

(1)

(d) A student uses 50 cm^3 of a zinc sulfate solution of 80 g/dm^3

What mass of zinc sulfate is dissolved in 50 cm^3 of this zinc sulfate solution?

_____

_____

_____

_____

Mass = _____ g

(2)

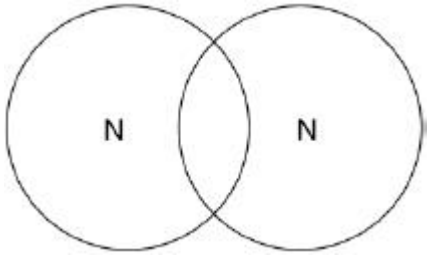
(Total 10 marks)

Q8.

This question is about structure and bonding.

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

Show only the electrons in the outer shell.



(2)

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

Answer in terms of nitrogen's structure.

_____

_____

_____

_____

_____

_____

(3)

(c) Graphite and fullerenes are forms of carbon.

Graphite is soft and is a good conductor of electricity.

Explain why graphite has these properties.

Answer in terms of structure and bonding.

_____

_____

_____

_____

_____

_____

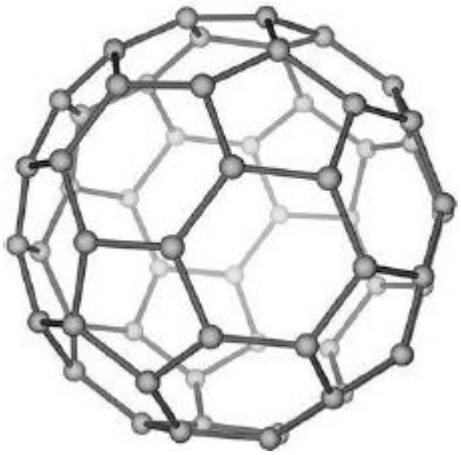
_____

_____

(4)

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

Figure 1



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

Suggest why Buckminsterfullerene is a good lubricant.

Use **Figure 1**.

_____

_____

_____

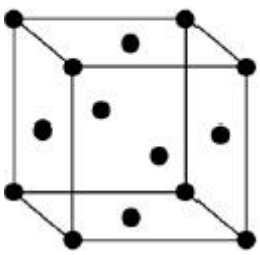
_____

(2)

Silver can form cubic nanocrystals.

Figure 2 represents a silver nanocrystal.

Figure 2



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

Calculate the surface area to volume ratio of the nanocrystal.

_____

_____

_____

_____

_____

Surface area to volume ratio = _____

(3)

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

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

_____

_____

_____

_____

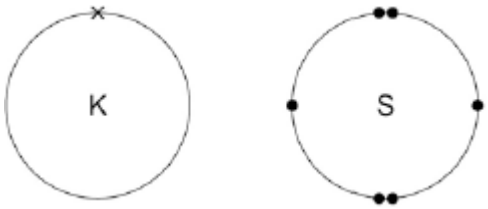
(2)

(Total 16 marks)

Q9.

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.

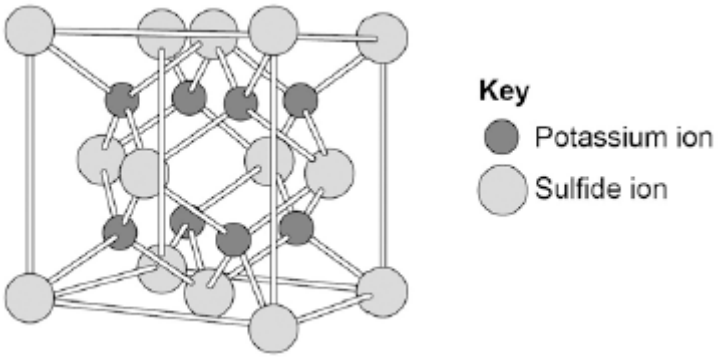
Give your answer in terms of electron transfer.

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.

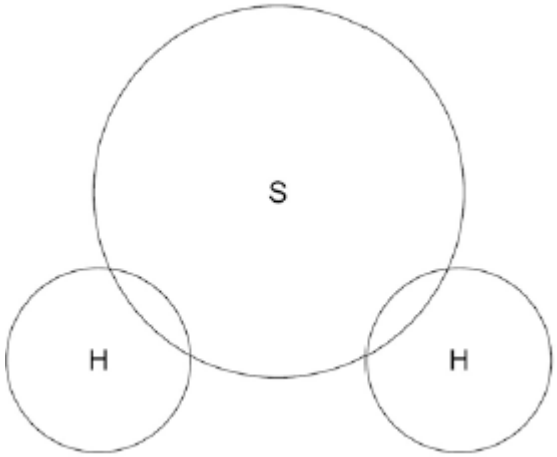
Give **one** reason why.

(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	Electrons are free to move
	There are no charged particles free to move
	Ions are free to move

	Weak intermolecular forces of attraction
Does not conduct electricity when molten	
	Bonds are weak
	Bonds are strong

(2)

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

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

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

Bonds are strong

(2)

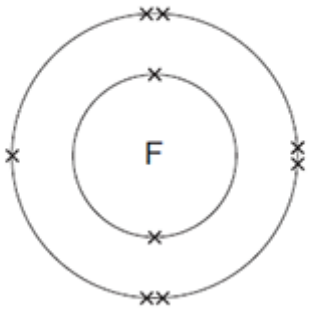
(Total 14 marks)

Q10.

This question is about fluorine.

(a) **Figure 1** shows the arrangement of electrons in a fluorine atom.

Figure 1



(i) In which group of the periodic table is fluorine?

Group _____

(1)

(ii) Complete the table below to show the particles in an atom and their relative masses.

Name of particle	Relative mass
Proton	
Neutron	1
	Very small

(2)

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

alkalis	**alloys**	**isotopes**

Atoms of fluorine with different numbers of neutrons are

called _____ .

(1)

(b) Sodium reacts with fluorine to produce sodium fluoride.

(i) Complete the word equation for this reaction.

sodium + _____ → _____

(1)

(ii) Complete the sentence.

Substances in which atoms of two or more different elements are chemically

combined are called _____ .

(1)

(iii) The relative formula mass (M_r) of sodium fluoride is 42.

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

ion	mole	molecule

The relative formula mass (M_r), in grams, of sodium fluoride is one

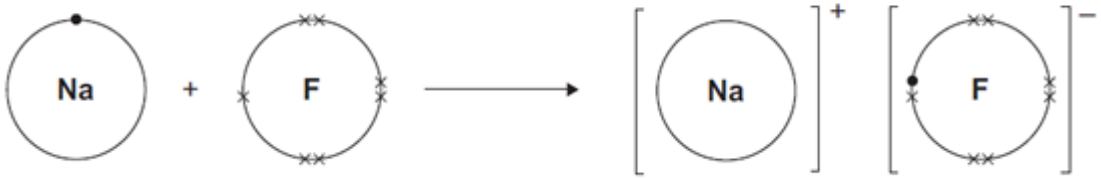
_____ of the substance.

(1)

(iv) **Figure 2** shows what happens to the electrons in the outer shells when a sodium atom reacts with a fluorine atom.

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

Figure 2



Use **Figure 2** to help you answer this question.

Describe, as fully as you can, what happens when sodium reacts with fluorine to produce sodium fluoride.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(v) Sodium fluoride is an ionic substance.

What are **two** properties of ionic substances?

Tick (✓) **two** boxes.

Dissolve in water	☐
Gas at room temperature	☐
High melting point	☐
Low boiling point	☐

(2)

(Total 13 marks)