Q1. Silicon dioxide (SiO_2) has a crystal structure similar to diamond.

(a) Give the name of the type of crystal structure shown by silicon dioxide.

.....

(1)

(b) Suggest why silicon dioxide does **not** conduct electricity when molten.

.....

.....

.....

(1)

(c) Silicon dioxide reacts with hydrofluoric acid (HF) to produce hexafluorosilicic acid (H_2SiF_6) and one other substance.

Write an equation for this reaction.

.....

(1)

(Total 3 marks)

Q2. Some airbags in cars contain sodium azide (NaN_3).

(a) Sodium azide is made by reacting dinitrogen monoxide gas with sodium amide ($NaNH_2$) as shown by the equation.

$$2NaNH_2 + N_2O \longrightarrow NaN_3 + NaOH + NH_3$$

Calculate the mass of sodium amide needed to obtain 550 g of sodium azide, assuming there is a 95.0% yield of sodium azide.
Give your answer to 3 significant figures.

.....

.....

.....

.....

.....

.....

.....

.....

(5)

(b) If a car is involved in a serious collision, the sodium azide decomposes to form sodium and nitrogen as shown in the equation.

$$2NaN_3(s) \longrightarrow 2Na(s) + 3N_2(g)$$

The nitrogen produced then inflates the airbag to a volume of 7.50×10^{-2} m^3 at a pressure of 150 kPa and temperature of 35 °C.

Calculate the minimum mass of sodium azide that must decompose.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(6)

(c) Sodium azide is toxic. It can be destroyed by reaction with an acidified solution of nitrous acid (HNO_2) as shown in the equation.

$$2NaN_3 + 2HNO_2 + 2HCl \longrightarrow 3N_2 + 2NO + 2NaCl + 2H_2O$$

(i) A 500 cm^3 volume of the nitrous acid solution was used to destroy completely 150 g of the sodium azide.

Calculate the concentration, in mol dm^{-3}, of the nitrous acid used.

.....

.....

.....

.....

.....

.....

(3)

(ii) Nitrous acid decomposes on heating.

Balance the following equation for this reaction.

.....HNO_2 ⟶ .....HNO_3 + ...NO + ...H_2O

(1)

(d) Sodium azide has a high melting point.

Predict the type of bonding in a crystal of sodium azide.
Suggest why its melting point is high.

Type of bonding .....

Reason for high melting point .....

.....

.....

.....

.....

(3)

(e) The azide ion has the formula N_3^-

(i) The azide ion can be represented as $N \equiv N - N^-$
One of these bonds is a co−ordinate bond.

On the following diagram, draw an arrowhead on one of the bonds to represent the direction of donation of the lone pair in the co−ordinate bond.

$$N \equiv N - N^-$$

(1)

(ii) Give the formula of a molecule that has the same number of electrons as the azide ion.

.....

(1)

(iii) Which is the correct formula of magnesium azide?

Tick (✓) **one** box.

Mg_3N ☐

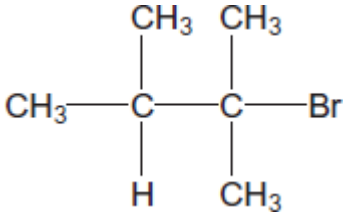
MgN ☐

MgN_6 ☐

Mg_3N_2 ☐

(1)
(Total 21 marks)

Q3.(a) The structure of the bromoalkane **Z** is



Give the IUPAC name for **Z**.

Give the general formula of the homologous series of straight-chain bromoalkanes that contains one bromine atom per molecule.

Suggest **one** reason why 1-bromohexane has a higher boiling point than **Z**.

.....

.....

.....

.....

.....

.....

.....

(Extra space) .....

.....

.....

(3)

(b) Draw the displayed formula of 1,2-dichloro-2-methylpropane.

State its empirical formula.

.....

.....

(2)
(Total 5 marks)

Q4.(a) Nickel is a metal with a high melting point.

(i) State the block in the Periodic Table that contains nickel.

.....

(1)

(ii) Explain, in terms of its structure and bonding, why nickel has a high melting point.

.....

.....

.....

.....

.....

(2)

(iii) Draw a labelled diagram to show the arrangement of particles in a crystal of nickel.
In your answer, include at least six particles of each type.

(2)

(iv) Explain why nickel is ductile (can be stretched into wires).

.....

.....

.....

(1)

(b) Nickel forms the compound nickel(II) chloride ($NiCl_2$).

(i) Give the full electron configuration of the Ni^{2+} ion.

.....

(1)

(ii) Balance the following equation to show how anhydrous nickel(II) chloride can be obtained from the hydrated salt using $SOCl_2$
Identify **one** substance that could react with both gaseous products.

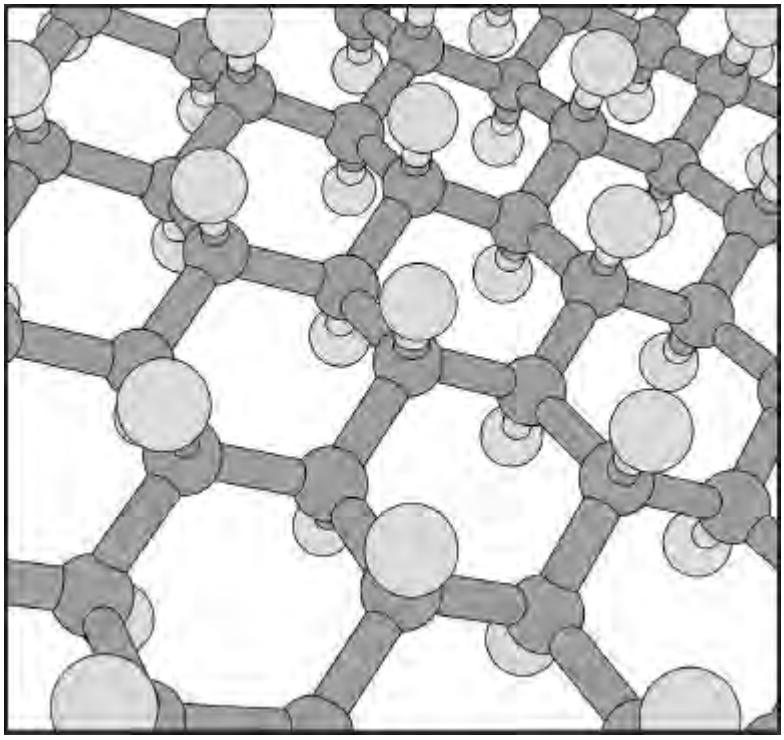
.....$NiCl_2.6H_2O(s)$ + ... $SOCl_2(g)$ ⟶ .....$NiCl_2(s)$ + ...$SO_2(g)$ + ...$HCl(g)$

Substance .....

(2)

(Total 9 marks)

Q5. In 2009 a new material called graphane was discovered. The diagram shows part of a model of the structure of graphane. Each carbon atom is bonded to three other carbon atoms and to one hydrogen atom.



(a) Deduce the type of crystal structure shown by graphane.

.....

(1)

(b) State how two carbon atoms form a carbon–carbon bond in graphane.

.....

.....

(1)

(c) Suggest why graphane does **not** conduct electricity.

.....

.....

(1)

(d) Deduce the empirical formula of graphane.

.....

(1)

(Total 4 marks)

Q6. Thallium is in Group 3 of the Periodic Table.

Thallium reacts with halogens to form many compounds and ions.

(a) Draw the shape of the $TlBr_3^{2-}$ ion and the shape of the $TlCl_4^{3-}$ ion.
Include any lone pairs of electrons that influence the shapes.

Name the shape made by the atoms in $TlBr_3^{2-}$ and suggest a value for the bond angle.

.....

(4)

(b) Thallium(I) bromide (TlBr) is a crystalline solid with a melting point of 480 °C.

Suggest the type of bonding present in thallium(I) bromide and state why the melting point is high.

.....

.....

.....

.....

.....

.....

(3)

(c) Write an equation to show the formation of thallium(I) bromide from its elements.

.....

(1)

(Total 8 marks)