1 Chlorine and its compounds have wide uses in chemistry.

(a) In drinking water, HC*l*O kills bacteria.

(i) Write an equation to show how HC*l*O can form in drinking water.

..... **[1]**

(ii) Some scientists believe that chlorine compounds should **not** be present in drinking water.

Suggest **one** reason why scientists may be worried by the presence of these compounds.

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..... **[1]**

(b) Chlorine reacts directly with Group 2 elements to form chlorides that are very soluble in water.

Aqueous chloride ions can be detected by adding aqueous silver nitrate.
The appearance of solid silver chloride, AgC*l*, confirms the presence of chloride ions.

(i) State the type of reaction that has taken place.

..... **[1]**

(ii) Write the ionic equation for this reaction.
Include state symbols.

..... **[1]**

(c) A student is given a sample of an unknown Group 2 chloride.

- The student dissolves 2.86 g of the chloride in water.
- The student adds excess aqueous silver nitrate.
- 8.604 g of solid silver chloride, AgC*l*, forms.

(i) Calculate the amount, in moles, of AgC*l* that forms.

The molar mass of AgC*l* = 143.4 g mol^{-1}.

answer = ... mol **[1]**

(ii) Deduce the amount, in moles, of the Group 2 chloride that the student dissolves.

Hence deduce the relative atomic mass and the identity of the Group 2 metal.
Give the relative atomic mass to **one** decimal place.

You **must** show your working.

relative atomic mass = ...

Group 2 metal = ... **[3]**

(d) Ammonium chloride, NH_4Cl, is a salt which has covalent bonding, dative covalent (coordinate) bonding and ionic bonding.

(i) What is a *dative covalent* (*coordinate*) bond?

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..... **[1]**

(ii) Give the formulae of the ions present in NH_4Cl.

..... **[1]**

(iii) Draw a '*dot-and-cross*' diagram to show the bonding in NH_4Cl.
Show the outer electrons only.

[2]

(e) A teacher heats potassium chlorate(V), $KClO_3$. The equation is given below.

$$2KClO_3(s) \longrightarrow 2KCl(s) + 3O_2(g)$$

(i) This is an example of a redox reaction.

What other type of reaction takes place?

..... **[1]**

(ii) The teacher heats 0.824 g of $KClO_3$.

Calculate the volume of oxygen produced, in cm^3, measured at room temperature and pressure.

Give your answer to the **nearest whole number**.

answer = ... cm^3 **[3]**

[Total: 16]

2 Many metallic elements react with dilute hydrochloric acid to form a solution containing a salt.

(a) Zinc reacts with dilute hydrochloric acid to form a solution of the salt, zinc chloride, $ZnCl_2$.

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

(i) Explain why $ZnCl_2$ is a salt.

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..... **[1]**

(ii) Predict the formula of the zinc salt that could be formed by adding an excess of zinc to phosphoric(V) acid, H_3PO_4.

..... **[1]**

(b) Group 2 elements also react with dilute hydrochloric acid.

Describe **and** explain the trend in reactivity of the Group 2 elements with dilute hydrochloric acid as the group is descended.

In your answer you should use appropriate technical terms, spelled correctly.

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..... **[5]**

[Total: 7]

3 Solids exist as lattice structures.

(a) Giant metallic lattices conduct electricity. Giant ionic lattices do not. If a giant ionic lattice is melted, the molten ionic compound will conduct electricity.

Explain these observations in terms of bonding, structure and particles present.

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..... **[3]**

(b) The solid lattice structure of ammonia, NH_3, contains hydrogen bonds.

(i) Draw a diagram to show hydrogen bonding between **two** molecules of NH_3 in a solid lattice.

Include relevant dipoles and lone pairs.

(ii) Suggest why ice has a higher melting point than solid ammonia. **[2]**

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..... **[2]**

(c) Solid SiO_2 melts at 2230 °C. Solid $SiCl_4$ melts at –70 °C. Neither of the liquids formed conducts electricity.

Suggest the type of lattice structure in solid SiO_2 and in solid $SiCl_4$ and explain the difference in melting points in terms of **bonding** and **structure**.

In your answer you should use appropriate technical terms, spelled correctly.

[5]

[Total: 12]

4 In the Periodic Table, the chemistry of elements in a group can often be predicted from the chemistry of just one element in the group.

(a) Ions of Group 7 elements take part in displacement reactions. These reactions can be used to compare the reactivities of the elements within Group 7.

A student adds aqueous solutions of halogens to test-tubes containing solutions of halide ions. The resulting mixtures are then shaken with cyclohexane, an organic solvent.

One of the student's results is shown in the table.

experiment number	experiment details	colour seen within the organic solvent
1	addition of Cl_2(aq) to I^-(aq) ions	
2	addition of Cl_2(aq) to Br^-(aq) ions	orange
3	addition of Br_2(aq) to Cl^-(aq) ions	

(i) Complete the table to show the expected colours. **[2]**

(ii) Write the ionic equation for the reaction taking place in experiment 2.

..... **[1]**

(iii) These three experiments alone are unable to confirm the order of reactivity for Cl_2, Br_2 and I_2.

Suggest **one** further displacement reaction which could be carried out to confirm the order of reactivity of Cl_2, Br_2 and I_2.

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..... **[1]**

(b) Chlorine gas reacts with water as shown below.

$$Cl_2(g) + H_2O(l) \longrightarrow HClO(aq) + HCl(aq)$$

(i) Using oxidation numbers, explain why this reaction is an example of disproportionation.

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..... **[3]**

(ii) State **one** benefit for public health, of the reaction between chlorine gas and water.

..... **[1]**

(c) Group 2 elements and compounds show periodic trends. One trend is shown by the effect of heat upon Group 2 carbonates.

A student carried out an experiment to find out the volume of carbon dioxide obtained by heating a weighed sample of magnesium carbonate.

The student placed a 1.47 g sample of $MgCO_3$ into a test-tube and heated it until there was no further change in mass.

The following reaction took place.

$$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$$

(i) What type of reaction is this?

..... **[1]**

(ii) What volume of CO_2, in dm^3, would have been given off when measured at room temperature and pressure?

The molar mass of $MgCO_3$ = 84.3 g mol^{-1}

answer = ...dm^3 **[2]**

(iii) The student repeated the experiment a further three times, using the same number of moles of $CaCO_3$, $SrCO_3$ and $BaCO_3$.

What trend in the behaviour of the Group 2 carbonates would be observed by the student?

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..... **[1]**

[Total: 12]

5 This question is about elements in Period 2 of the Periodic Table.

(a) Lithium has a giant metallic structure and a boiling point of 1342 °C.

Describe, with the aid of a labelled diagram, the structure and bonding in lithium and explain why lithium has a high boiling point.

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..... **[3]**

(b) Fluorine is a gas at room temperature and has a very low boiling point of –188 °C.

(i) Draw a '*dot-and-cross*' diagram to show the bonding in a fluorine molecule. Show the outer electrons only.

[1]

(ii) Explain why fluorine has a low boiling point.

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..... **[2]**

(c) Fluorine reacts with lithium at room temperature to form a white crystalline solid, lithium fluoride. Lithium fluoride is a good conductor of electricity when molten but not when solid.

(i) Draw a '*dot-and-cross*' diagram to show the bonding in lithium fluoride.
Show the outer electrons only.

[2]

(ii) Explain why lithium fluoride conducts electricity when molten but **not** when solid.

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..... **[2]**

(d) Fluorine reacts with boron, B, to form the fluoride BF_3.

(i) Suggest an equation for this reaction.

..... **[1]**

(ii) Name the shape of, and state the bond angles in, a BF_3 molecule.

Explain why BF_3 has this shape.

In your answer, you should use appropriate technical terms spelt correctly.

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..... **[4]**

(e) Nitrogen can also form a fluoride, NF_3, which has a permanent dipole.

Explain why NF_3 has a permanent dipole.

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..... **[2]**

(f) Describe and explain the trend in atomic radii of the elements Li to F across Period 2 of the Periodic Table.

In your answer, you should use appropriate technical terms, spelt correctly.

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..... **[4]**

[Total: 21]