1 The chlor-alkali industry is an important part of the UK chemical industry.

The raw material is brine, a concentrated aqueous solution of sodium chloride, NaC*l*(aq). Two products that can be manufactured from brine are chlorine and sodium hydroxide — hence the name chlor-alkali.

(a) Bleach can be made by reacting chlorine with cold aqueous sodium hydroxide. A solution of bleach contains the chlorate compound NaC*l*O.

Write the equation for the reaction taking place.

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

(b) The systematic name for NaC*l*O is sodium chlorate(I). Other chlorate compounds exist, such as $NaClO_3$.

(i) Give the systematic name for $NaClO_3$.

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

(ii) When heated, $NaClO_3$ disproportionates as shown in the equation below.

$$4NaClO_3 \longrightarrow 3NaClO_4 + NaCl$$

Using oxidation numbers, explain why this is a disproportionation reaction.

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

(c) Chlorine has been added to drinking water for over a century. Recently, some scientists have put forward the case for **not** chlorinating drinking water. This is because chlorine may react with organic compounds in the water to form CH_3Cl.

(i) State **one** valid reason that supports the scientists' case and state **one** reason why chlorine should be added to drinking water.

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

(ii) Draw a '*dot-and-cross*' diagram to show the bonding in a molecule of CH_3Cl.

Show **outer** electrons only.

[1]

(iii) Name the shape of a molecule of CH_3Cl .

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

(d) A sample of brine is a concentrated aqueous solution of sodium chloride, NaCl(aq).

Describe a simple chemical test that you could carry out to show that brine contains aqueous chloride ions. How would you confirm that no other halide ions are present?

Include an ionic equation in your answer.

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

[Total: 13]

2 This question compares the bonding, structure and properties of sodium and sodium oxide.

(a) Sodium, Na, is a metallic element.

Explain, with the aid of a labelled diagram, what is meant by the term *metallic bonding*.

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

(b) Sodium reacts with oxygen to form sodium oxide, Na_2O, which is an ionic compound.

(i) Write the equation for the reaction of sodium with oxygen to form sodium oxide.

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

(ii) State what is meant by the term *ionic bond*.

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

(iii) Draw a '*dot-and-cross*' diagram to show the bonding in Na_2O.

Show **outer** electrons only.

[2]

(c) Compare and explain the electrical conductivities of sodium and sodium oxide in the solid and liquid states.

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

[Total: 12]

3 Solid potassium, K, solid potassium bromide, KBr, and ice, H_2O, all exist as lattices.

Their melting points are shown in the table below.

(a) Complete the table.

solid	**melting point / °C**	**type of lattice**
K	63	giant metallic
KBr	734	
H_2O	0	

[2]

(b) Explain why there is a difference in the melting points of K, KBr and H_2O.

In your answer you should refer to the types of particle, the types of forces between the particles and the relative strength of the forces between the particles in solid K, KBr and H_2O.

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

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.... **[6]**

(c) Potassium metal reacts with water.

$$2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$$

0.2346 g of potassium is reacted with excess water.

Calculate the volume of gas formed.

The gas volume is measured in cm^3 at room temperature and pressure.

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

[Total: 11]

4 Linus Pauling was a Nobel prize winning chemist who devised a scale of electronegativity.

Some Pauling electronegativity values are shown in the table.

element	electronegativity
B	2.0
Br	2.8
N	3.0
F	4.0

(a) What is meant by the term *electronegativity*?

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

(b) Show, using δ+ and δ– symbols, the permanent dipoles on each of the following bonds.

N—F N

[1]

(c) Boron trifluoride, BF_3, ammonia, NH_3, and sulfur hexafluoride, SF_6, are all covalent compounds. The shapes of their molecules are different.

(i) State the shape of a molecule of SF_6.

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

(ii) Using outer electron shells only, draw *'dot-and-cross'* diagrams for molecules of BF_3 and NH_3.

Use your diagrams to explain why a molecule of BF_3 has bond angles of 120° and NH_3 has bond angles of 107°.

BF_3	**NH_3**

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

(iii) Molecules of BF_3 contain polar bonds, but the molecules are non-polar.

Suggest an explanation for this difference.

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[Total: 11]

5 This question is about different models of bonding and molecular shapes.

(a) Magnesium sulfide shows ionic bonding.

(i) What is meant by the term *ionic bonding*?

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

(ii) Draw a '*dot-and-cross*' diagram to show the bonding in magnesium sulfide.
Show outer electron shells only.

[2]

(b) '*Dot-and-cross*' diagrams can be used to predict the shape of covalent molecules.

Fluorine has a covalent oxide called difluorine oxide, F_2O. The oxygen atom is covalently bonded to each fluorine atom.

(i) Draw a '*dot-and-cross*' diagram of a molecule of F_2O.
Show outer electron shells only.

[2]

(ii) Predict the bond angle in an F_2O molecule. Explain your answer.

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

(c) Liquid ammonia, NH_3, and water, H_2O, both show hydrogen bonding.

(i) Draw a labelled diagram to show hydrogen bonding between two molecules of liquid **ammonia**.

[3]

(ii) Water has several anomalous properties as a result of its hydrogen bonding.

Describe and explain **one** anomalous property of water which results from hydrogen bonding.

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[Total: 13]