

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, $\text{NaCl}(\text{aq})$. 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 NaClO .

Write the equation for the reaction taking place.

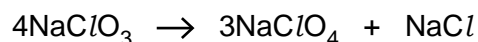
..... [1]

(b) The systematic name for NaClO 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.



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, $\text{NaCl}(\text{aq})$.

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]

2 Chemists use the Periodic Table to predict the behaviour of elements.

(a) Early attempts at developing a Periodic Table arranged elements in order of increasing atomic mass.

(i) State which two elements from the **first twenty** elements of the modern Periodic Table are not arranged in order of increasing atomic mass.

..... [1]

(ii) Why does the modern Periodic Table **not** arrange some elements, such as those in **a(i)**, in order of increasing atomic mass?

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..... [1]

(b) Magnesium and strontium are in Group 2 of the Periodic Table.

(i) When reacted with oxygen, magnesium forms a white powder called magnesium oxide.

Write the equation for the reaction of magnesium with oxygen.

..... [1]

(ii) Magnesium reacts with dilute acids.

Describe what you would expect to see when magnesium ribbon is added to an excess of dilute hydrochloric acid.

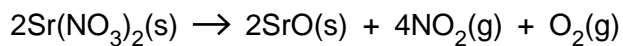
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..... [2]

(iii) Strontium reacts in a similar way to magnesium.

Describe **one** difference you might observe if strontium, instead of magnesium, was reacted with dilute hydrochloric acid.

..... [1]

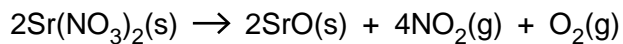
- (d) The element strontium forms a nitrate, $\text{Sr}(\text{NO}_3)_2$, which decomposes on heating as shown below.



- (i) Using oxidation numbers, explain why the reaction involves both oxidation and reduction.

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..... [3]

- (ii) A student heats 5.29 g of $\text{Sr}(\text{NO}_3)_2$ and collects the gas at room temperature and pressure, RTP.



Calculate the volume of gas, in dm^3 , obtained by the student at RTP.

Molar mass of $\text{Sr}(\text{NO}_3)_2 = 211.6 \text{ g mol}^{-1}$.

answer = dm^3 [3]

[Total: 18]

3 Chemists have developed models for bonding and structure which are used to explain different properties.

(a) Ammonia, NH_3 , is a covalent compound.

(i) Explain what is meant by a *covalent bond*.

..... [1]

(ii) Draw a '*dot-and-cross*' diagram to show the bonding in NH_3 .

Show **outer** electrons only.

[1]

(iii) Name the shape of the ammonia molecule.

Explain, using your '*dot-and-cross*' diagram, why ammonia has this shape and has a bond angle of 107° .

shape:

explanation:

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..... [3]

(b) Ammonia reacts with hydrogen chloride, HCl , to form ammonium chloride, NH_4Cl .

NH_4Cl is an ionic compound containing NH_4^+ and Cl^- ions.

(i) Complete the electron configuration of the Cl^- ion.

$1s^2$ [1]

(ii) Draw a 'dot-and-cross' diagram to show the bonding in NH_4^+ .

Show **outer** electrons only.

[1]

(iii) State the shape of, and bond angle in, an NH_4^+ ion.

shape:

bond angle: [2]

(iv) A student investigated the conductivity of ammonium chloride.

She noticed that when the ammonium chloride was solid it did **not** conduct electricity. However, when ammonium chloride was dissolved in water, the resulting solution did conduct electricity.

Explain these observations.

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..... [2]

(c) Ammonium compounds such as ammonium sulfate, $(\text{NH}_4)_2\text{SO}_4$, can be used as fertilisers.

(i) Write a balanced equation to show how ammonium sulfate could be formed by the reaction between aqueous ammonia and sulfuric acid.

..... [1]

(ii) Ammonium sulfate is an example of a salt formed when an acid is neutralised by a base.

Explain what is meant by the term *salt*.

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..... [1]

(iii) Why is ammonia acting as a base in this neutralisation?

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..... [1]

(iv) What is the relative formula mass of $(\text{NH}_4)_2\text{SO}_4$?

Give your answer to **one** decimal place.

..... [1]

[Total: 15]