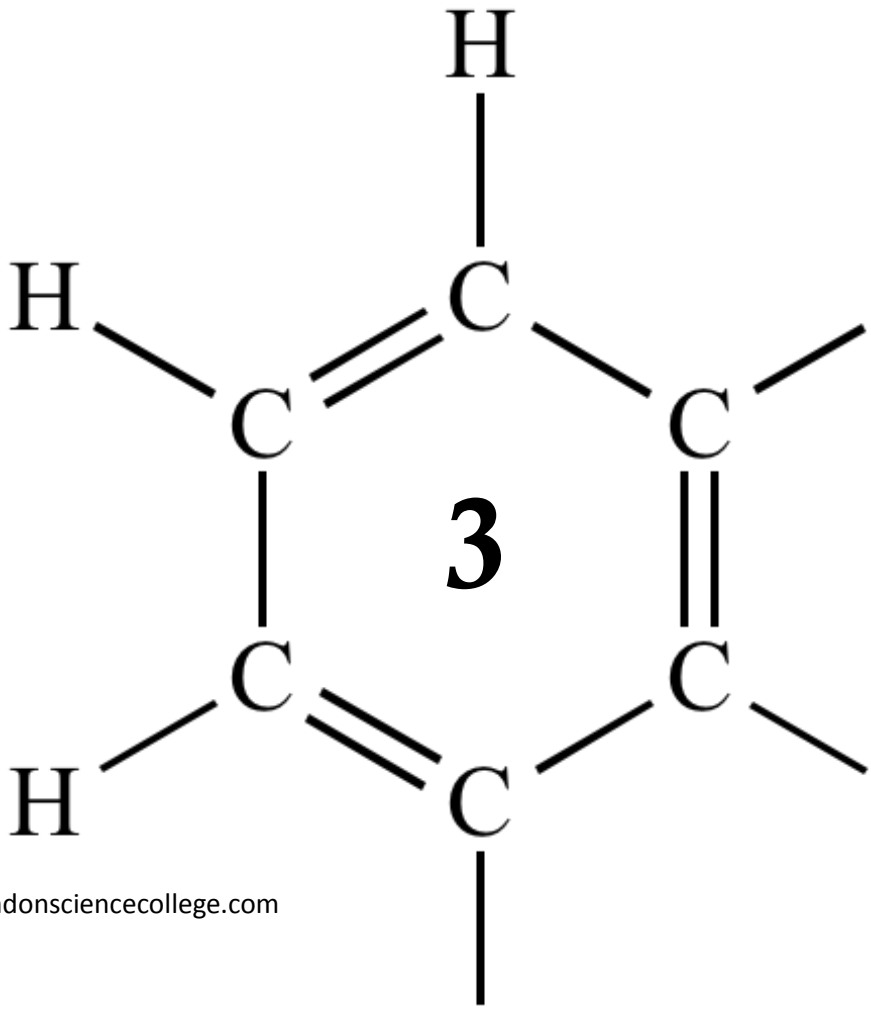
LONDON SCIENCE COLLEGE

AQA AS CHEMISTRY

HALOGENS



3

1 (a) Give the **formula** of a Group 2 metal hydroxide used in agriculture.

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(1)

(b) Identify a sodium halide that does **not** undergo a redox reaction when added as a solid to concentrated sulfuric acid.

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(1)

(c) Chlorine gas reacts with cold dilute sodium hydroxide solution to form sodium chloride and another chlorine-containing compound, **X**.

Give the **formula** of **X**.

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(1)

(d) Give the **formula** of the substance responsible for the orange colour when chlorine gas is bubbled through an aqueous solution of sodium bromide.

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(1)

(e) Solid sodium iodide undergoes a redox reaction with concentrated sulfuric acid.

Give the **formula** for each of the following in this reaction.

Formula of the solid reduction product .....

Formula of the oxidation product .....

(2)

(f) Draw the structure of each of the following organic compounds.

(i) The hydrocarbon that is a chain isomer of methylpropene, but does **not** exhibit E–Z stereoisomerism.

(1)

(ii) The alcohol that is a position isomer of butan-2-ol.

(1)

(iii) The hydrocarbon that has a peak, due to its molecular ion, at *m/z* = 44 in its mass spectrum.

(1)

(iv) The bromoalkane that reacts with sodium cyanide to produce propanenitrile.

(1)
(Total 10 marks)

2 (a) Some scientists thought that the waste water from a waste disposal factory contained **two** sodium halides.

They tested a sample of the waste water.

They added three reagents, one after the other, to the same test tube containing the waste water.

The table below shows their results.

Reagent added	Observations
1. Silver nitrate solution (acidified with dilute nitric acid)	A cream precipitate formed
2. Dilute ammonia solution	A yellow precipitate remained
3. Concentrated ammonia solution	The yellow precipitate did not dissolve

(i) Identify the yellow precipitate that did **not** dissolve in concentrated ammonia solution.
Write the **simplest** ionic equation for the formation of this precipitate from silver ions and the correct halide ion.
Identify the other sodium halide that must be present in this mixture of two sodium halides.

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(3)

(ii) Give **one** reason why the silver nitrate solution was acidified before it was used in this test.

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(1)

(iii) The method that the scientists used could **not** detect one type of halide ion. Identify this halide ion.
Give **one** reason for your answer.

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(2)

(b) The scientists thought that the waste water also contained dissolved barium ions. An aqueous solution of sodium sulfate can be used to test for the presence of dissolved barium ions.

Write the **simplest** ionic equation for the reaction between barium ions and sulfate ions to form barium sulfate.

State what is observed in this reaction.

Give a use for barium sulfate in medicine and explain why this use is possible, given that solutions containing barium ions are poisonous.

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(4)

(c) The scientists also analysed the exhaust gases from an incinerator used to destroy waste poly(ethene).
Mass spectrometry showed that there was a trace gas with a precise M_r = 28.03176 in the exhaust gases from the incinerator.

The table below contains some precise relative atomic mass data.

Atom	Precise relative atomic mass
^{12}C	12.00000
^{1}H	1.00794
^{16}O	15.99491

Use the data to show that the trace gas is ethene. Show your working.

Suggest why both ethene and carbon monoxide might have been identified as the trace gas if the scientists had used relative atomic masses to a precision of only one decimal place.

Write an equation for the incomplete combustion of ethene to form carbon monoxide and water only.

Ethene is used to make poly(ethene).
Draw the displayed formula for the repeating unit of poly(ethene).
Name this type of polymer.

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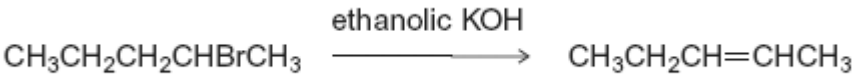
(5)
(Total 15 marks)

3 Organic reaction mechanisms help chemists to understand how the reactions of organic compounds occur.
The following conversions illustrate a number of different types of reaction mechanism.

(a) When 2-bromopentane reacts with ethanolic KOH, two structurally isomeric alkenes are formed.

(i) Name and outline a mechanism for the conversion of 2-bromopentane into pent-2-ene as shown below.



(4)

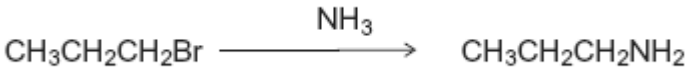
(ii) Draw the structure of the other structurally isomeric alkene produced when 2-bromopentane reacts with ethanolic KOH.

(1)

(b) Name and outline a mechanism for the following conversion.

(5)

(c) Name and outline a mechanism for the following conversion.



(5)
(Total 15 marks)

4 Copper(II) sulfate solution, together with copper(II) carbonate ($CuCO_3$) powder, can be used to determine the identity of three solutions **A, B** and **C**. The three solutions are known to be hydrochloric acid, barium chloride, and sodium chloride.

In **Experiment 1** a small amount of copper(II) carbonate powder was added to each of the three solutions.

In **Experiment 2** a dropping pipette was used to add 2 cm^3 of copper(II) sulfate solution to each of the three solutions.

The results of these experiments are shown in the table below.

	Experiment 1 Addition of copper(II) carbonate powder	**Experiment 2** Addition of copper(II) sulfate solution
Solution **A**	no visible change	white precipitate
Solution **B**	no visible change	no visible change
Solution **C**	effervescence (bubbles of gas)	no visible change

(a) Use the observations in the table to deduce which of the solutions, **A, B** or **C** is

hydrochloric acid .....

barium chloride .....

(2)

(b) Explain why a precipitate was formed when copper(II) sulfate solution was added to solution **A**.
Write an equation for the reaction that occurred.

Explanation .....

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Equation .....

(2)

(c) Suggest the identity for the colourless gas produced when copper(II) carbonate powder was added to solution **C**.

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(1)

(d) Identify the two reagents that could be used in a test to confirm that the solutions contained chloride ions, **not** bromide ions. State what would be observed on addition of each reagent.

Reagent 1 .....

Observation 1 .....

.....

Reagent 2 .....

Observation 2 .....

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(4)

(e) Copper(II) sulfate is toxic. Suggest **one** safety precaution you would take to minimise this hazard when wiping up a spillage of copper(II) sulfate solution.

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(1)
(Total 10 marks)

5 The presence of halide ions in solution can be detected by adding silver nitrate solution and dilute nitric acid.

(a) State the purpose of the nitric acid in this test.

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(1)

(b) Explain how the addition of an ammonia solution can be used to confirm that a precipitate is silver bromide.

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(2)
(Total 3 marks)

6 Reactions that involve oxidation and reduction are used in a number of important industrial processes.

(a) Iodine can be extracted from seaweed by the oxidation of iodide ions.
In this extraction, seaweed is heated with MnO_2 and concentrated sulfuric acid.

(i) Give the oxidation state of manganese in MnO_2

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(1)

(ii) Write a half-equation for the reaction of MnO_2 in acid to form Mn^{2+} ions and water as the only products.

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(1)

(iii) In terms of electrons, state what happens to the iodide ions when they are oxidised.

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(1)

(b) Chlorine is used in water treatment. When chlorine is added to cold water it reacts to form the acids HCl and HClO
The following equilibrium is established.

$$Cl_2(aq) + H_2O(l) \rightleftharpoons H^+(aq) + Cl^-(aq) + HClO(aq)$$

(i) Give the oxidation state of chlorine in Cl_2 and in HClO

Cl_2 ….....

HClO .....

(2)

(ii) Deduce what happens to this equilibrium as the HClO reacts with bacteria in the water supply. Explain your answer.

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(2)

(c) Concentrated sulfuric acid is reduced when it reacts with solid potassium bromide.
Concentrated sulfuric acid is **not** reduced when it reacts with solid potassium chloride.

(i) Write the two half-equations for the following redox reaction.

$$2H^+ + 2Br^- + H_2SO_4 \longrightarrow Br_2 + SO_2 + 2H_2O$$

Half-equation 1

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Half-equation 2

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(2)

(ii) Write an equation for the reaction of solid potassium chloride with concentrated sulfuric acid.

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(1)

(iii) Explain why chloride ions are weaker reducing agents than bromide ions.

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(2)

(Total 12 marks)

7 Chlorine is a useful industrial chemical.

(a) Chlorine gas is used in the manufacture of chlorine-containing organic compounds.

(i) Write equations for the following steps in the mechanism for the reaction of chlorine with ethane to form chloroethane (CH_3CH_2Cl).

Initiation step

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First propagation step

.....

Second propagation step

.....

A termination step producing butane.

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(4)

(ii) Give **one** essential condition and name the type of mechanism in this reaction of chlorine with ethane.

Essential condition .....

Type of mechanism .....

(2)

(b) Chlorine reacts with cold water.

(i) Write an equation for this reaction.

.....

(1)

(ii) Give **one** large-scale application of the use of chlorine in water. Explain why it is used in this application even though chlorine is very toxic. Do **not** include cost.

Example of application…….....

Explanation of use .....

(2)

(iii) Two different chlorine-containing compounds are formed when chlorine reacts with cold, dilute sodium hydroxide solution. One of these compounds is sodium chloride. Name the other chlorine-containing compound formed.

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(1)

(c) Chlorine is used in the extraction of bromine from seawater.

(i) Write the **simplest** ionic equation for the reaction of chlorine with bromide ions.

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(1)

(ii) Explain why bromine has a higher boiling point than chlorine.

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(2)

(Total 13 marks)

8 Desalination is a technique for making drinking water by the removal of salts from sea water. It is used in parts of the world where fresh water is in short supply. A problem with this technique is the increase in the concentration of salts, particularly of sodium chloride, in the effluent (the solution returned to the sea).

Desalination uses a process called reverse osmosis. In this process, sea water under high pressure is passed over a special membrane which allows only pure water to pass through it.

The owners of a desalination plant have asked for the effluent to be analysed at different operating pressures. This is needed to find an **approximate** value for the maximum operating pressure that gives an effluent that has a minimum harmful effect on the environment.

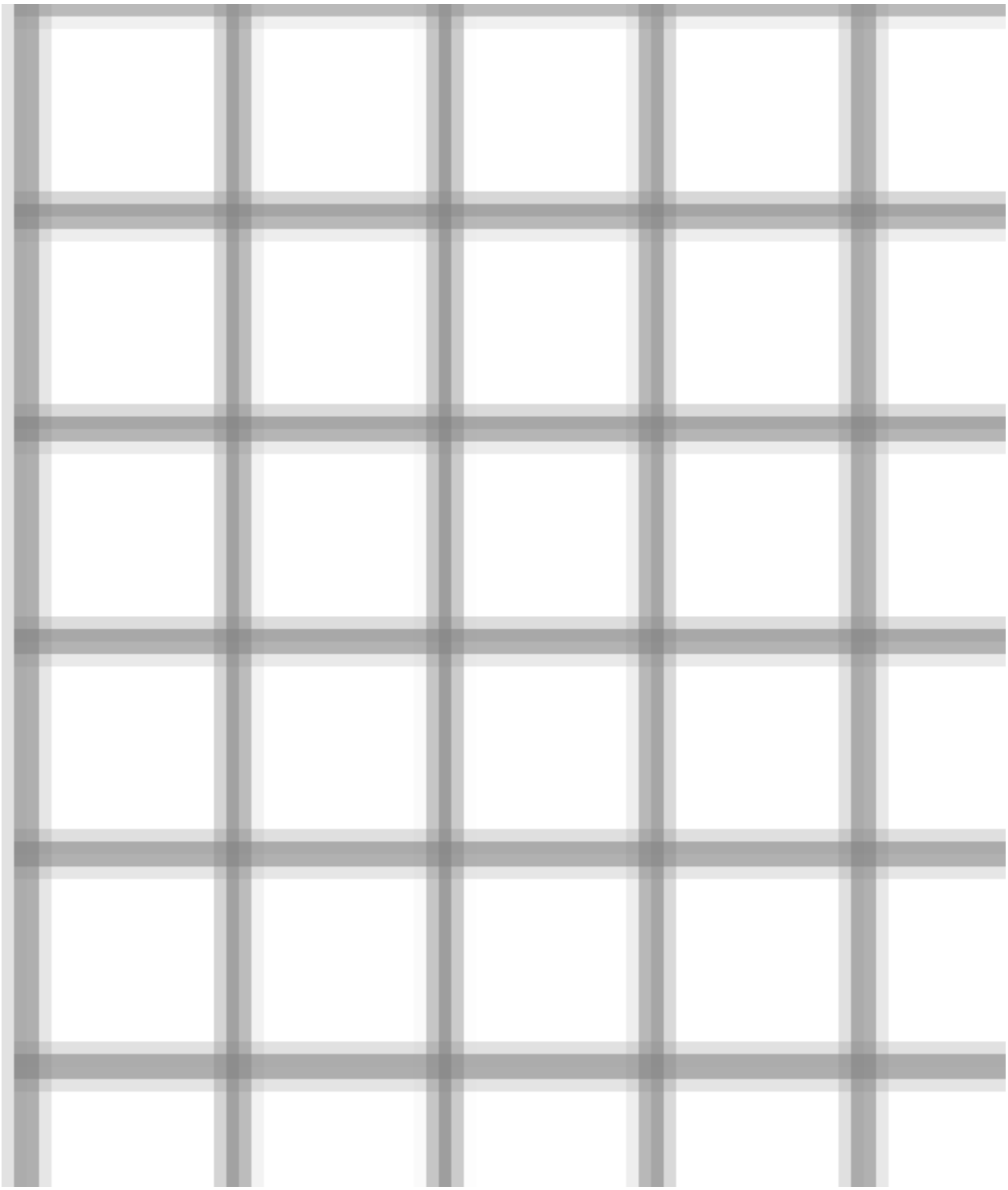
A chemist sampled the effluent at different pressures. For each pressure, a 250 cm^3 sample of effluent was taken in a measuring cylinder and poured into a weighed beaker. The water was evaporated by heating and the beaker reweighed. The following results were obtained.

Experiment	**1**	**2**	**3**	**4**	**5**	**6**
Pressure / MPa	0.1	0.5	1.0	2.5	4.0	8.0
Beaker mass before heating / g	55.3	55.5	55.0	55.1	55.3	56.3
Beaker mass after heating / g	62.5	64.9	65.3	66.6	67.5	69.4
Mass of solid in beaker / g						

(a) Complete the table above to determine the mass of solid that remains in the beaker at each pressure.

Plot a graph of mass of solid (y-axis) against pressure on the graph paper.

Draw a smooth curve through the points.



(4)

(b) To minimise harmful effects on the environment, the concentration of sodium chloride in the effluent should not exceed 44.0 g dm^{-3}. Use your graph to find a value for the pressure, in MPa, that the chemist should advise to be the maximum operating pressure.

Assume that all the solid left in the beaker is sodium chloride.

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(1)

(c) In Experiment **1** the 250 cm^3 sample of the effluent contained the same amount of sodium chloride as the original sea water. Calculate the concentration, in mol dm^{-3}, of sodium chloride in sea water.

Assume that all the solid left in the beaker is sodium chloride.
Show your working.

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(2)

(d) For the measuring cylinder and the balance, the maximum total errors are shown below. These errors take into account multiple measurements.

250 cm^3 measuring cylinder	±1.0 cm^3
balance	±0.1 g

Estimate the maximum percentage error in using these pieces of apparatus, and hence estimate their combined error.

You should use the mass of the solid in the beaker in Experiment **1** to estimate the percentage error in using the balance.
Show your working.

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(2)

(e) Consider your graph.

(i) Is the curve good enough to use with confidence to predict the intermediate values? Explain your answer.

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(1)

(ii) Identify the anomalous results, if any.

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(1)

(f) Give **one** reason why the owners of the plant were satisfied with the maximum operating pressure determined in part (b) despite the combined errors you have calculated in part (d).

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(1)

(g) (i) Suggest **one** harmful effect that effluent with a high concentration of sodium chloride might have if it is returned to the sea.

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(1)

(ii) Suggest **one** low cost method of treating the effluent so that this harmful effect could be reduced.

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(1)

(h) Bromine can be obtained by reacting the bromide ions in the concentrated sea water using chlorine gas in a displacement reaction. Write an equation for this reaction.

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(1)

(i) The solid obtained by the chemist after heating the effluent to dryness was treated with concentrated sulfuric acid. A vigorous reaction resulted, including the formation of a purple vapour of iodine. Give **one** reason why this procedure could **not** be adapted to be an economic method for producing iodine from sea water on an industrial scale.

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(1)

(j) Sea water contains some organic material. After removing all the water, by heating the effluent samples strongly, it was noticed that the solid formed contained black particles. These particles are insoluble in water.

On heating very strongly in air these particles burned to give a colourless gas.

(i) Identify these black particles.

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(1)

(ii) Suggest how these black particles are formed by heating the effluent strongly.

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(1)

(iii) Suggest how a sample of the black particles could be separated from the solid formed.

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(2)

(k) The water produced by some desalination plants is acidic due to the presence of hydrochloric acid. Lime, $Ca(OH)_2$, is added to neutralise this acid. Write an equation for this reaction.

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(1)

(l) Lime is used because it is relatively inexpensive and available in large quantities. Identify **one** other large-scale use of lime.

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(1)

(Total 22 marks)