The Halogens

1(a).   This question is about halogens.

A student adds a solution of bromine in an organic solvent to two test tubes.

The student adds aqueous sodium chloride to one test tube, and aqueous sodium iodide to the other test tube.

The student shakes the mixtures, allows them to settle, and records the colour of the organic layer in each mixture.

Sodium halide	Colour of organic layer
Sodium chloride	orange
Sodium iodide	violet

Explain how the student's results provide evidence for the trend in reactivity of the halogens down group 17(7) and write an ionic equation for any reaction that takes place.

Use your chemical knowledge to explain the trend in reactivity.

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[5]

(b). Chlorine is used in water treatment.

State **one** benefit and **one** risk of using chlorine in water treatment.

Benefit

Risk

----

[1]

2. This question is about some elements in Period 4 of the periodic table.

Bromine reacts with concentrated sodium hydroxide at 50 °C as in the equation below.

$3Br_2 + 6NaOH$ $5NaBr + NaBrO_3 + 3H_2O$

i. Write the systematic name for $NaBrO_3$.

--**[1]**

ii. This reaction is an example of disproportionation.

Use oxidation numbers to explain why. Include the meaning of the term **disproportionation.**

--**[3]**

3. This question is about halogens and halides.

The boiling points of the halogens are shown in the table.

Halogen	Boiling point / K
fluorine	85
chlorine	239
bromine	332
iodine	457
astatine	503

Explain the trend in boiling points of the halogens.

--**[3]**

4. This question is about the halogen group of elements and some of their compounds.

The halogens show trends in their properties down the group.

The boiling points of three halogens are shown below.

Halogen	Boiling point / °C
Chlorine	−35
Bromine	59
Iodine	184

Explain why the halogens show this trend in boiling points.

---**[3]**

5(a). Iodine can be used for the small-scale purification of drinking water.

    i.   Iodine reacts with water as shown below.

$$I_2 + H_2O \rightleftharpoons HI + HIO$$
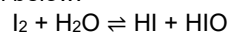
Using oxidation numbers, explain why this reaction is a disproportionation.

---**[3]**

    ii.   Chlorine is used to purify water on a large scale.

State **one** disadvantage of using chlorine for the purification of drinking water.

---**[1]**

[1]

(b). This question is about halogens.

Bromine is used to extract iodine from a solution containing iodide ions.

  i. Write an ionic equation for the reaction.

---**[1]**

  ii. Explain why iodine is less reactive than bromine.

--**[3]**

6. Bromine disproportionates when it reacts with potassium hydroxide solution.

Suggest an equation for this reaction.

---**[1]**

7. On gently heating, the compound $KClO_3$ reacts as shown in the equation.

  $4KClO_3(s) \rightarrow KCl(s) + 3KClO_4(s)$

This reaction is an example of disproportionation.
  i. State what is meant by *disproportionation* and use oxidation numbers to show that disproportionation has taken place.

--**[3]**

    ii.   What is the systematic name for $KClO_4$?

           --**[1]**

8(a). Precipitation reactions can be used to distinguish between halide ions.

    i.   State the reagent needed for these precipitation reactions.

   --**[1]**

    ii.   How would the appearance of the precipitates allow you to distinguish between chloride, bromide and iodide ions?

        Chloride
        ....

        Bromide
        ....

        Iodide
        ....

                                                          [1]

(b). This question is about properties of the halogens and halide ions.

Bromine can be extracted by bubbling chlorine gas through concentrated solutions containing bromide ions.

    i.   Write the electron configuration of a bromide ion, in terms of sub-shells.

   --**[1]**

    ii.   Write an ionic equation for this reaction and state why this reaction takes place in terms of reactivity of the halogens.

   --**[2]**

(c). Chlorine is used in water treatment.

State **one** benefit and **one** risk of chlorine in water treatment.

Benefit

....

Risk

....

--**[1]**

9. A student carries out test-tube experiments to prove the trend in reactivity of halogens.

The student is provided with the following solutions:

- bromine water
- aqueous iodine
- aqueous barium chloride
- aqueous magnesium bromide
- aqueous calcium iodide.

Chlorine gas and chlorine water are **not** available.

The student carries out the **minimum** number of test-tube experiments using these solutions in the presence of cyclohexane (an organic solvent).

- State the solutions that need to be added together in order to prove the trend in reactivity of the halogens, using the **minimum** number of test-tube experiments.
- Describe the colour seen in the organic solvent at the end of each test-tube experiment.
- Write an ionic equation for **one** reaction that takes place.

---**[5]**

10. The Group 7 element chlorine reacts with sodium hydroxide, NaOH, under different conditions to give different products.

i. Chlorine reacts with aqueous sodium hydroxide to form bleach.

Write the equation and state the conditions for this reaction.

equation

....

conditions

....

[2]

ii. Under different conditions, chlorine reacts differently with aqueous sodium hydroxide.

A disproportionation reaction takes place as shown below.

$$3Cl_2(g) + 6NaOH(aq) \rightarrow 5NaCl(aq) + NaClO_3(aq) + 3H_2O(l)$$

State what is meant by disproportionation and show that disproportionation has taken place in this reaction.

Use oxidation numbers in your answer.

---**[3]**

11. A student carries out the following experiment to investigate the reaction between hexane and chlorine. The chlorine is made by reaction of aqueous sodium chlorate(I) with dilute hydrochloric acid.

Procedure	Observations
1 cm^3 of hexane is mixed with 1 cm^3 dilute aqueous sodium chlorate(I) in a test-tube.	The mixture forms two colourless layers.
1 cm^3 dilute hydrochloric acid is slowly added to the mixture.	The acid mixes with the lower layer, which turns a pale green colour.
The tube is then stoppered and shaken.	The pale green colour moves to the upper layer, leaving the lower layer colourless.
The tube is placed under a bright light and shaken at regular intervals for about 10 minutes. The stopper is loosened regularly to release any pressure.	The pale green colour slowly disappears leaving two colourless layers after about 10 minutes.

    i.   The reaction between aqueous sodium chlorate(I) and dilute hydrochloric acid produces aqueous sodium chloride as well as chlorine.

        Suggest an equation for this reaction.

[2]

    ii.   Outline a simple practical test that would confirm the presence of chloride ions in the lower layer, and give the expected result.

        test: ....

        result: ....

[2]

    iii.   Name the apparatus that could be used to separate the two liquid layers present at the end of the experiment.

[1]

12. i. Complete the electron configuration of a bromide **ion**.

$1s^2$

....

[1]

ii. A student adds a small volume of aqueous silver nitrate to an aqueous solution of bromide ions in a test-tube. The student then adds a similar volume of dilute aqueous ammonia to the same test-tube.

Describe what the student would see in the test-tube after the addition of aqueous ammonia.

[1]

iii. Write an ionic equation for any precipitation reaction which occurs in the student's tests.

Include state symbols.

[1]

13(a). A student bubbles chlorine gas through aqueous potassium iodide. A reaction takes place.

i. State what the student would observe.

[1]

ii. Write the ionic equation for this reaction.

Include state symbols.

[1]

(b). Chlorine gas can be added to a cold, dilute alkaline solution to form bleach.

Write the equation for this reaction.

[1]

END OF QUESTION PAPER