1. Compound **A** is a chloride of a Period 3 element.

A student carries out the 2 steps below to find the formula of compound **A**.

Step 1 The student adds 5.00×10^{-4} mol of compound **A** to water.
A colourless solution is formed.

Step 2 The colourless solution reacts with exactly 60.0 cm^3 of 2.50×10^{-2} mol dm^{-3} $AgNO_3(aq)$ to form a white precipitate.

i. Write an ionic equation, with state symbols, for the reaction in **Step 2**.

_____ **[1]**

ii. Determine the formula of compound **A**.

formula of **A** = ... **[3]**

2. In the UK, water companies typically treat drinking water with chlorine gas at a concentration of 0.500 mg dm^{-3} or less.

Which statement about UK drinking water is correct?

A Chlorine in drinking water can catalyse the breakdown of ozone.

B Chlorine may form toxic chlorinated hydrocarbons.

C Drinking water with a chlorine gas concentration of 0.500 mg dm^{-3} contains 2.12×10^{18} chlorine molecules in each dm^3.

D In hot weather, chlorine can vaporise from drinking water to cause global warming.

Your answer ☐ **[1]**

3. Which reaction does **not** show disproportionation of chlorine?

A $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$

B $Cl_2 + H_2O \rightarrow HCl + HClO$

C $2ClO_2 + 2NaOH \rightarrow NaClO_2 + NaClO_3 + H_2O$

D $2NaOH + Cl_2 \rightarrow NaCl + NaClO + H_2O$

Your answer ☐ **[1]**

4. Chlorine has many uses.

i. Chlorine is used to treat water in large-scale water treatment plants.

Suggest why chlorine is added to water in large-scale water treatment plants.

_____

[1]

ii. Sea water contains aqueous bromide ions.

Chlorine is used to extract bromine from sea water.

Construct the ionic equation for this reaction and explain why chlorine is suitable for this extraction of bromine but iodine is **not**.

Equation _____

Explanation _____

_____

[2]

5. Which equation does **not** represent a disproportionation reaction?

A $Cl_2 + H_2O \rightarrow HClO + HCl$
B $Cl_2 + 2NaOH \rightarrow NaClO + NaCl + H_2O$
C $4KClO_3 \rightarrow KCl + 3KClO_4$
D $4HCl + MnO_2 \rightarrow MnCl_2 + Cl_2 + 2H_2O$

Your answer ☐ **[1]**

6. Which statement explains the trend in boiling points down the halogens group?

A The bond enthalpy of the covalent bonds increases.
B The halogens become less electronegative.
C The induced dipole-dipole interactions (London forces) become stronger.
D The reactivity of the halogens decreases.

Your answer ☐ **[1]**

7. This question is about the first 36 elements in the periodic table:

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr

From these 36 elements **only**, write the symbol for the element(s) that fit each description.

The element that forms 1– ions most readily

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

8. Which statement explains the trend in boiling points down the halogens group?

A Covalent bonds become stronger.
B Induced dipole–dipole interactions (London forces) become stronger.
C Ionic bonds become stronger.
D Permanent dipole–dipole interactions become stronger.

Your answer ☐ **[1]**

9(a). This question is about halogens and halogen compounds.

Seawater contains very small quantities of dissolved iodide ions.

The concentration of potassium iodide, KI, in seawater is 0.150 g dm^{-3}.

Iodine can be extracted by bubbling chlorine gas through seawater.

Explain why chlorine is more reactive than iodine and determine the volume, in dm^3, of seawater that is needed to manufacture 1.00 tonne of iodine, I_2.

[6]

(b). Chlorine reacts with calcium hydroxide to form $Ca(OCl)_2$, which is the active ingredient in bleaching powder.

$2Cl_2 + 2Ca(OH)_2 \rightarrow CaCl_2 + Ca(OCl)_2 + 2H_2O$

This is a disproportionation reaction.

State what is meant by **disproportionation** and use oxidation numbers to show that disproportionation has taken place.

[3]

(c). The student sets up an experiment to compare the rates of hydrolysis of 2-bromopropane and 2-iodopropane.

The student uses the method below.

Step 1 Place two test tubes, both containing aqueous silver nitrate and ethanol, in a water bath at 60 °C.

Step 2 Add five drops of 2-bromopropane to one test tube and five drops of 2-iodopropane to the other test tube.

Step 3 Record the time taken for a precipitate to appear in each test tube.

i. Complete the table below to show the formula and colour of each precipitate formed.

Haloalkane	Formula of precipitate	Colour of precipitate
2-bromopropane		
2-iodopropane		

[2]

ii. Predict which precipitate would form first and explain the difference in the rates of hydrolysis of 2-bromopropane and 2-iodopropane.

[1]

10(a). This question is about halogens and practical tests

Chlorine gas reacts with dilute sodium hydroxide, NaOH(aq). This is a disproportionation reaction. One of the products has the formula NaC*l*O.

i. What is meant by the term **disproportionation**?

[1]

ii. Construct the equation for the reaction of chlorine with dilute sodium hydroxide.

Use your equation to explain that disproportionation has taken place.

Equation .....

Explanation .....

[3]

(b). A student is supplied with aqueous solutions of ionic compounds **B** and **C**.

Compound **B** is a chloride, bromide or iodide of a Group 1 element.

Compound **C** is a chloride, bromide or iodide of a Group 2 element.

The molar masses of **B** and **C** are both in the range 100–115 g mol^{-1}.

Use this information and test-tube tests to show how the student could identify the halide present in **B** and **C** and the formulae of **B** and **C**.

Explain your reasoning.

In your answer, include observations, colours and equations.

[5]

11. What is the correct explanation for the trend in the boiling points of chlorine, bromine, and iodine down the group?

A Bond enthalpy increases.
B Chemical reactivity decreases.
C Electronegativity decreases.
D London forces increase.

Your answer ☐ **[1]**

12. An aqueous solution contains a mixture of chloride, bromide and iodide ions.

$AgNO_3(aq)$ is added to this mixture, followed by an excess of dilute $NH_3(aq)$.

The resulting mixture is then filtered.

Which compound(s) is/are present in the residue on the filter paper?

A AgCl only
B AgCl and AgBr
C AgBr only
D AgBr and AgI

Your answer ☐ **[1]**

13. This question is about redox reactions.

'Calcium hypochlorite', $Ca(ClO)_2$, is an ionic compound used in 'bleaching powder'.

The ClO^- ion in $Ca(ClO)_2$ is the active ingredient that kills bacteria.

Calcium hypochlorite is prepared by reacting chlorine gas with calcium hydroxide.

$2Cl_2(g) + 2Ca(OH)_2(s) \rightarrow Ca(ClO)_2(s) + CaCl_2(s) + 2H_2O(l)$ **Equation 2.1**

i. 420 dm^3 of chlorine, measured at RTP, is reacted with an excess of $Ca(OH)_2$.

The solid products are dissolved in water to form 4.00 m^3 of solution.

Calculate the concentration of $Ca(ClO)_2(aq)$ in this solution, in mol dm^{-3}.

Give your answer to an **appropriate** number of significant figures and in standard form.

concentration = ... mol dm^{-3} **[3]**

ii. Calcium hypochlorite, $Ca(ClO)_2$, is heated. The $Ca(ClO)_2$ decomposes to form $CaCl_2$ and $Ca(ClO_3)_2$. This is a disproportionation reaction.

Write an equation for this decomposition and explain, using oxidation numbers, why this is a disproportionation reaction.

equation _____

_____

explanation _____

_____

_____

_____

[3]

14. Two students plan to investigate **Equilibrium 4.1**, shown below.

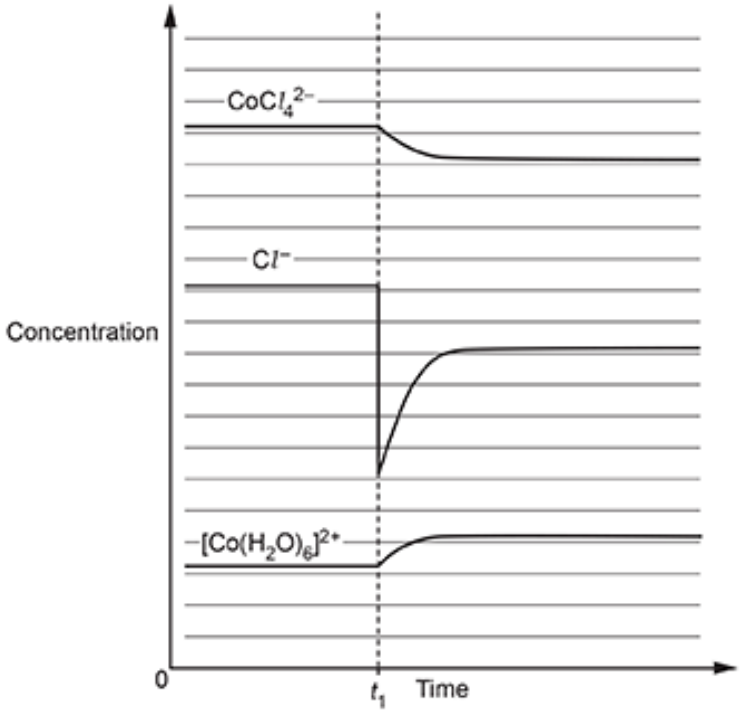
$CoCl_4^{2-}(aq) + 6H_2O(l) \rightleftharpoons [Co(H_2O)_6]^{2+}(aq) + 4Cl^-(aq)$ **Equilibrium 4.1**

blue pink

The students investigate how addition of aqueous silver nitrate, $AgNO_3(aq)$, affects the equilibrium position in **Equilibrium 4.1**.

The graph shows the changes in the equilibrium concentrations of $CoCl_4^{2-}$, Cl^- and $[Co(H_2O)_6]^{2+}$ after addition of the $AgNO_3(aq)$.

The $AgNO_3(aq)$ is added at time = t_1



i. Explain why the Cl^- concentration drops sharply at time = t_1.

[1]

ii. Explain the changes in concentration of $CoCl_4^{2-}$, Cl^- and $[Co(H_2O)_6]^{2+}$ after time = t_1.
Refer to **Equilibrium 4.1** in your answer.

[3]