Questions

Q1.

This question is about iron(II) salts.

Describe a chemical test, and the expected result, to show that sulfate ions are present in a solution of iron(II) sulfate in water.

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(Total for question = 2 marks)

Q2.

This question is about halogens and redox reactions.

The boiling temperatures of three halogens are shown in the table.

Halogen	Boiling temperature / °C
chlorine	−35
bromine	59
iodine	184

Explain why the boiling temperatures increase from chlorine to iodine.

(2)

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(Total for question = 2 marks)

Q3.

This question is about chlorine and its compounds.

When chlorine gas is dissolved in water, it reacts according to the equation

$$Cl_2 + H_2O \rightarrow HCl + HClO$$

The chloric(I) acid (HClO) produced is much more effective as a disinfectant than dissolved chlorine.
Chloric(I) acid is a weak acid and has little effect on the pH of the water.

Swimming pools usually have a chlorine content of 1 – 3 ppm.
Use the equation to explain one **disadvantage** of a chlorine content that is much lower than 1 ppm and one **disadvantage** of a chlorine content that is much higher than 3 ppm.

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(Total for question = 4 marks)

Q4.

An inorganic salt **A** contains one cation and one anion.
The results of two tests on salt **A** are shown in the table.

Test	Observation
Add aqueous sodium hydroxide to solid **A**. Warm the mixture. Test any gas evolved with damp red litmus paper.	A gas was evolved. The gas turned red litmus paper blue.
Add dilute nitric acid followed by aqueous silver nitrate to an aqueous solution of **A**.	A cream precipitate formed.

Describe additional tests, with the results, that will confirm the identity of the **anion** in the cream precipitate.

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(Total for question = 2 marks)

Q5.

Compound **C** is a pink crystalline solid containing two cations and one anion.

Three tests were carried out on **C**. The observation made for each test was recorded in the table.

Test	Observation	Inference
Test 1 Aqueous sodium hydroxide was added to solid **C** and the mixture warmed The gas evolved was tested with damp red litmus paper	The red litmus paper turned blue	The gas evolved was ..... One of the cations in **C** is .....
Test 2 Concentrated hydrochloric acid was added to an aqueous solution of **C**	The pink solution turned blue	The other cation in **C** is ..... The formula of the complex ion in the blue solution is .....
Test 3 Dilute hydrochloric acid and aqueous barium chloride were added to an aqueous solution of **C**	A white precipitate formed	The white precipitate is ..... The anion in **C** is .....

Give a reason why dilute hydrochloric acid is needed in **Test 3**.

(1)

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(Total for question = 1 mark)

Q6.

This question is about the elements in Group 7 of the Periodic Table and some of their compounds.

The standard electrode potentials for two half-equations involving bromine are given.

$$Br_2(aq) + 2e^- \rightleftharpoons 2Br^-(aq) \qquad E^\ominus = +1.09\,V$$

$$2HOBr(aq) + 2H^+(aq) + 2e^- \rightleftharpoons Br_2(aq) + 2H_2O(l) \qquad E^\ominus = +1.57\,V$$

(i) Explain why the disproportionation of bromine in water is **not** thermodynamically feasible under standard conditions. Include the overall equation for the disproportionation and its $E^\ominus_{cell}$ value.

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(ii) Bromine disproportionates in water to a small extent at 298 K.

Give a possible reason why this reaction occurs.

(1)

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(Total for question = 4 marks)

Q7.

This question is about some redox reactions of chlorine, bromine and iodine.

Chlorine undergoes disproportionation when it reacts with **hot** aqueous sodium hydroxide solution.

(i) Complete the ionic equation for this reaction. State symbols are not required.

(1)

..... Cl_2 + ... OH^- → ..... Cl^- + ... ClO_3^- + ... H_2O

(ii) Explain, in terms of oxidation numbers, why this is a disproportionation reaction.

(2)

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(Total for question = 3 marks)

Q8.

This question is about redox chemistry.

A different ion containing chlorine is formed if the solution of aqueous hydroxide ions is hot.

Give the formula of the chlorine-containing ion **and** the oxidation number of chlorine in this ion.

(2)

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(Total for question = 2 marks)

Q9.

This question is about halogens and redox reactions.

Potassium halides react with concentrated sulfuric acid to form potassium hydrogensulfate and the different products shown in the table.

Potassium halide	Products
potassium chloride	hydrogen chloride
potassium bromide	hydrogen bromide, bromine and sulfur dioxide
potassium iodide	hydrogen iodide, iodine, hydrogen sulfide and sulfur

By referring to any changes in oxidation numbers when these halides react with concentrated sulfuric acid, explain which halide is the strongest reducing agent.

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(Total for question = 3 marks)

Q10.

This question is about some reactions of chlorine and hydrogen chloride.

Hydrogen chloride gas dissolves in water to form hydrochloric acid.

(i) Hydrogen chloride gas does not conduct electricity.

Hydrochloric acid is a good conductor of electricity.
Give a reason for this change in conductivity.

(1)

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(ii) When concentrated hydrochloric acid on a glass rod is held above a concentrated ammonia solution, a white smoke is observed.

Write an equation, including state symbols, for the reaction that produces the white smoke.

(2)

(iii) Hydrochloric acid is added to a test tube containing a sample of solid sodium carbonate.

Give **two** observations.

(2)

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(iv) Describe an experiment to enable you to accurately determine the concentration of an approximately 1 mol dm^{-3} solution of hydrochloric acid, using a solution of sodium hydroxide of concentration 1.00 mol dm^{-3}. Details of the calculation are not required.

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(Total for question = 10 marks)

Q11.

An inorganic salt **A** contains one cation and one anion.
The results of two tests on salt **A** are shown in the table.

Test	Observation
Add aqueous sodium hydroxide to solid **A**. Warm the mixture. Test any gas evolved with damp red litmus paper.	A gas was evolved. The gas turned red litmus paper blue.
Add dilute nitric acid followed by aqueous silver nitrate to an aqueous solution of **A**.	A cream precipitate formed.

Deduce the **name** of salt **A**.

(2)

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(Total for question = 2 marks)

Q12.

Compound **C** is a pink crystalline solid containing two cations and one anion.

Three tests were carried out on **C**. The observation made for each test was recorded in the table.

Test	Observation	Inference
Test 1 Aqueous sodium hydroxide was added to solid **C** and the mixture warmed The gas evolved was tested with damp red litmus paper	The red litmus paper turned blue	The gas evolved was ..... One of the cations in **C** is .....
Test 2 Concentrated hydrochloric acid was added to an aqueous solution of **C**	The pink solution turned blue	The other cation in **C** is ..... The formula of the complex ion in the blue solution is .....
Test 3 Dilute hydrochloric acid and aqueous barium chloride were added to an aqueous solution of **C**	A white precipitate formed	The white precipitate is ..... The anion in **C** is .....

(b) Write the **ionic** equation for the reaction between the cation in **C** and sodium hydroxide producing the gas in **Test 1**.

State symbols are not required.

(1)

(Total for question = 1 mark)

Q13.

This question is about redox chemistry.

(i) Bromine can be extracted from seawater containing bromide ions using chlorine.

Write the ionic equation for this reaction. State symbols are not required.

(1)

(ii) Identify **one** hazard associated with carrying out this reaction in a school laboratory and a safety precaution other than wearing a laboratory coat and eye protection.

(2)

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(Total for question = 3 marks)

Q14.

The halogens are elements in Group 7 of the Periodic Table.

Halide ions can be identified by their reaction with silver nitrate.

(i) Write the **ionic** equation for the reaction between aqueous solutions of sodium iodide and silver nitrate.
Include state symbols.

(2)

(ii) A solution containing 0.010 mol of a halide ion was reacted with excess silver nitrate and produced 1.88 g of precipitate.

Identify the halide ion.
Justify your answer.

(2)

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(Total for question = 4 marks)

Q15.

Tests are carried out on aqueous solutions of two salts, **X** and **Y**.

X contains one cation and one anion.

The observations for each test are recorded in the table.

(i) Complete the table by writing the names or formulae of the species.

(2)

Test	Observation	Inference
Test 1 Add aqueous sodium hydroxide to an aqueous solution of **X**	A green precipitate forms The precipitate turns brown on the top after a few minutes	The cation in **X** is .....
Test 2 To an aqueous solution of **X**, add dilute hydrochloric acid followed by aqueous barium chloride	A white precipitate forms	The anion in **X** is .....

(ii) Write the ionic equation for the reaction between the cation in **X** and aqueous sodium hydroxide in **Test 1**. Include state symbols.

(2)

(iii) Give a reason why the green precipitate turns brown on the top after a few minutes.

(1)

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(iv) Give a reason why dilute hydrochloric acid is needed in **Test 2**.

(1)

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(Total for question = 6 marks)

Q16.

This question is about redox chemistry.

(i) Write an ionic half-equation for the reduction of chlorine molecules to chloride ions.

State symbols are not required.

(1)

(ii) Write an ionic half-equation for the oxidation of chlorine molecules to chlorate(I) ions in the presence of cold, aqueous hydroxide ions.

State symbols are not required.

(1)

(iii) Combine the two equations in (i) and (ii) to give the ionic equation for the reaction of chlorine molecules with cold, aqueous hydroxide ions.

(1)

(iv) Use your answer to (iii) to explain why the reaction is described as a **disproportionation** reaction.

(2)

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(Total for question = 5 marks)

Q17.

This question is about some halogens and their compounds.

The intermolecular attractions between halogen molecules are London forces.

(i) Describe how London forces form between halogen molecules.

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(ii) The boiling temperatures of chlorine and bromine are shown in the table.

Halogen	Boiling temperature / °C
chlorine	–34
bromine	59

Explain why bromine has a higher boiling temperature than chlorine.

(2)

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(Total for question = 5 marks)

Q18.

Compound **C** is a pink crystalline solid containing two cations and one anion.

Three tests were carried out on **C**. The observation made for each test was recorded in the table.

(i) Complete the statements in the inference column by writing the names or formulae of the species.

(6)

Test	Observation	Inference
Test 1 Aqueous sodium hydroxide was added to solid **C** and the mixture warmed The gas evolved was tested with damp red litmus paper	The red litmus paper turned blue	The gas evolved was ..... One of the cations in **C** is .....
Test 2 Concentrated hydrochloric acid was added to an aqueous solution of **C**	The pink solution turned blue	The other cation in **C** is ..... The formula of the complex ion in the blue solution is .....
Test 3 Dilute hydrochloric acid and aqueous barium chloride were added to an aqueous solution of **C**	A white precipitate formed	The white precipitate is ..... The anion in **C** is .....

(ii) Use the results of the tests in (i) to give a formula of **C**.
Do not include water of crystallisation.

(1)

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(Total for question = 7 marks)

Q19.

This question is about some halogens and their compounds.

A student carries out experiments to determine the order of reactivity of three halogens: bromine, chlorine and iodine.
The student is provided with aqueous solutions of the following five substances:

- bromine
- iodine
- potassium chloride
- potassium bromide
- potassium iodide.

The student has **no** access to chlorine gas or chlorine water.
The student uses cyclohexane, an organic solvent, to identify the halogen present at the end of each experiment.

The student carries out the **smallest** number of experiments required to determine the order of reactivity of the halogens.

Describe the experiments and the expected observations.

Include in your answer **ionic** equations for any reactions that occur.

State symbols are **not** required.

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(Total for question = 5 marks)

Q20.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

The halogens are elements in Group 7 of the Periodic Table.

Sodium chlorate(I) is a bleaching agent.

(i) Sodium chlorate(I) can be made by the reaction of chlorine with sodium hydroxide.

Show, by using oxidation numbers, that this reaction is disproportionation.

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

(2)

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(ii) A different bleaching agent can be made by the reaction of chlorine with sodium hydroxide under different conditions.

Balance this equation.

$$.....NaOH + ...Cl_2 \rightarrow NaClO_3 + ...NaCl + ...H_2O$$

(1)

(iii) What conditions are required for the reaction in (b)(ii)?

(1)

- ☐ **A** cold and dilute alkali
- ☐ **B** cold and concentrated alkali
- ☐ **C** hot alkali
- ☐ **D** excess chlorine

(Total for question = 4 marks)

Q21.

This question is about the reactions of the halogens and their salts.

The reaction that occurs between chlorine and sodium hydroxide depends on the temperature.

(i) At room temperature the reaction that occurs is

$$Cl_2 + NaOH \rightarrow NaClO + NaCl$$

Explain, with reference to oxidation numbers, why this is a disproportionation reaction.

(2)

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(ii) With hot sodium hydroxide solution, a different disproportionation reaction occurs. Sodium chlorate(V) is one of the products.

Complete the equation for this reaction. State symbols are not required.

(2)

..... Cl_2^+ ..... NaOH →

(Total for question = 4 marks)

Q22.

(i) Give the physical states of chlorine and iodine at room temperature and pressure.

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(ii) Predict the physical state of astatine under these conditions. Justify your answer.

(1)

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(Total for question = 2 marks)

Q23.

This question is about the reactions of the halogens and halide ions.

Potassium iodate(V) can be prepared by adding solid iodine to a **hot** aqueous solution of potassium hydroxide.

The equation for the reaction is

$$3I_2 + 6KOH \rightarrow KIO_3 + 5KI + 3H_2O$$

Potassium iodate(V) can be separated from the other reaction product using their differing solubilities in water.

	Solubility in water at 25 °C / mol dm^{-3}
KI	8.92
KIO_3	0.43

(i) Outline a procedure that you could use to obtain a sample of dry, solid potassium iodate(V) from the reaction mixture.

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(ii) Describe how you would show that iodide ions are present in an aqueous solution of potassium iodide.

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(Total for question = 5 marks)

Q24.

Aqueous sodium carbonate and aqueous sodium sulfate are both colourless solutions.

Give the reagent and the observation to show the presence of carbonate ions.

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(Total for question = 2 marks)

Q25.

Aqueous sodium carbonate and aqueous sodium sulfate are both colourless solutions.

Give the reagent and the observation to show the presence of sulfate ions.

(2)

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(Total for question = 2 marks)

Q26.

Write the equation for the reaction of chlorine with cold, dilute sodium hydroxide solution to form bleach. Name this type of reaction.

(2)

Type of reaction

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(Total for question = 2 marks)

Q27.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

This question is about chlorine and its compounds.

Potassium chlorate(V) can be produced by passing chlorine gas into hot, concentrated potassium hydroxide solution.

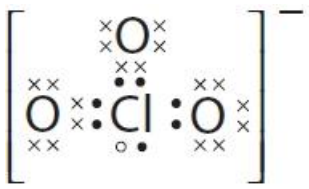
$$3Cl_2 + 6KOH \rightarrow 5KCl + KClO_3 + 3H_2O$$

(i) This reaction is an example of

(1)

- ☐ **A** oxidation only
- ☐ **B** reduction only
- ☐ **C** disproportionation
- ☐ **D** decomposition

(ii) A dot-and-cross diagram for the chlorate(V) ion (ClO_3^-) is shown.



Key
• = chlorine electrons
○ = an added electron
× = oxygen electrons

Predict the shape and bond angle (O—Cl—O) of the chlorate(V) ion. Justify your answer.

(4)

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(Total for question = 5 marks)

Q28.

Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

This question is about the reactions of the halogens and halide ions.

(i) When chlorine gas is bubbled through an aqueous solution of potassium iodide, the reaction involves

(1)

☐ **A** oxidation only

☐ **B** reduction only

☐ **C** redox

☐ **D** disproportionation

(ii) Cyclohexane was added to the resulting solution from (i). The mixture was shaken and then allowed to stand for a few minutes. Two layers were formed.

[Density: aqueous layer solution = 1.10 g cm^{-3}, cyclohexane layer = 0.78 g cm^{-3}]
The colour of the **lower** layer was

(1)

☐ **A** pale yellow

☐ **B** purple

☐ **C** red

☐ **D** pale green

(Total for question = 2 marks)

Q29.

This question is about the reactions of the halogens and their salts.

The potassium halides react with concentrated sulfuric acid to form hydrogen halides.

(i) The equation for this reaction for potassium chloride can be written

$$KCl + H_2SO_4 \rightarrow HCl + KHSO_4$$

The hydrogen chloride does not react further.
State why this reaction is not a redox reaction.

(1)

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(ii) On descending Group 7, the hydrogen halides become better reducing agents.

Explain how the reactions of potassium chloride, potassium bromide and potassium iodide with concentrated sulfuric acid provide evidence for this statement.
No explanation of the trend is required.

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(Total for question = 4 marks)

Q30.

This question is about some redox reactions of chlorine, bromine and iodine.

An **excess** of aqueous potassium bromide was added to chlorine water and the solution turned orange.

(i) Write an equation for this reaction. State symbols are not required.

(1)

(ii) Silver nitrate solution was added to the mixture in (i) and excess dilute ammonia solution was then added to the precipitate formed.

Only some of the precipitate dissolved.

Deduce why only **some** of the precipitate dissolved.

(3)

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(iii) Aqueous potassium bromide was added to aqueous iodine, instead of chlorine water. There was no reaction.

Give a reason why no reaction occurred.

(1)

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(Total for question = 5 marks)

Q31.

This question is about tests for ions.

An aqueous solution is suspected to be potassium bromide and is tested for the presence of the anion.

(i) Write the **name** of the reagent used to test for the anion.

(1)

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(ii) State the expected result of this test and the **formula** of the product.

(2)

Result of test

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Formula of the product

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(Total for question = 3 marks)

Mark Scheme

Q1.

Question Number	Acceptable Answer	Additional Guidance	Mark
	A description that makes reference to the following points: • (add hydrochloric acid / nitric acid then) add barium chloride / barium nitrate (solution) **(1)** • white precipitate / white solid **(1)**	Ignore omission of acid Do not award just Barium ions / Ba^{2+} M2 is dependent on M1, with the exception of just Ba^{2+} given as reagent	**(2)**

Q2.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points:	An answer that states 'covalent bonds break' or 'bonds between atoms break' or refers to 'ions' scores (0) overall Allow reverse argument for M1 and M2	**(2)**
	• from chlorine to iodine / down the group, the number of electrons (in the molecule / atom) increases / changes from 34 to 106 / 17 to 53 **(1)**	Allow iodine has more / most electron shells (than chlorine and/or bromine) Ignore 'the size of the atoms /molecules increases from chlorine to iodine' Do not allow incorrect numbers of electrons	
	• so the strength of the London / instantaneous dipole-(induced) dipole forces increases / there are more London / instantaneous dipole-(induced) dipole forces **and** more energy is needed to separate the molecules **(1)**	Allow iodine has the strongest London force **and** most energy is needed to separate the molecules Allow more energy is need to overcome / break the London forces / bonds instead of separate the molecules Allow dispersion forces / van der Waals forces for London forces Ignore higher temperature needed to separate the molecules Do not award dipole-dipole forces / just 'intermolecular forces'	

Q3.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points: Lower than 1 ppm • HClO will be low(er) **(1)** • ineffective (as a disinfectant) **(1)** Higher than 3 ppm • HCl will be high(er) **(1)** • any relevant effect of increased HCl **(1)**	Ignore reference to amount of Cl_2 being too low M2 dependent on correct M1 M4 dependent on correct M3 Award effects including corrosive, alters or lowers pH NB: Do not award high(er) pH Award increases acidity / strongly acidic / toxicity Award any reasonable negative effect on swimmers e.g. irritation / irritant Ignore just 'harmful' / just 'dangerous' Ignore reference to amount of Cl_2 being too high and its effects	**(4)**

Q4.

Question Number	Acceptable Answer	Additional Guidance	Mark
	A description that makes reference to the following points: • add (excess) dilute ammonia / dilute NH_3 (to the precipitate) **and** the precipitate is insoluble /does not dissolve **(1)** • add (excess) concentrated (aqueous) ammonia / concentrated NH_3 (to the precipitate) **and** it is soluble / dissolves / forms a colourless solution **(1)**	Allow ammonium hydroxide for ammonia Ignore pure ammonia / ammonia with no concentration / ammonia gas Allow no change for the observation Allow 'if it dissolves it is not bromide' Allow redissolves for soluble **Note** If no other mark is awarded allow (1) for adding dilute and concentrated ammonia with no / incorrect observation(s) **Alternative test:** add concentrated sulfuric acid **(1)** brown fumes **(1)**	**(2)**

Q5.

Question Number	Acceptable Answers	Additional Guidance	Mark
	An answer that makes reference to the following point:	Allow equation for the reaction with acid e.g. $2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$	**(1)**
	• to react with / remove any carbonate / sulfite / sulfate(IV) (ions)	Allow to prevent any other ions forming a precipitate (with barium ions / Ba^{2+}) Allow to rule out the possibility of carbonate / sulfite / sulfate(IV) ions giving a false result Ignore just 'to remove impurities / other (an)ions' / 'react with precipitates' Ignore to dissolve barium carbonate / sulfite Ignore reference to hydrogencarbonate	

Q6.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to the following points: • balanced equation **(1)** • calculation of $E^{\ominus}_{cell}$ value **(1)** • $E^{\ominus}_{cell}$ / answer is negative / <0 **and** the reaction is not (thermodynamically) feasible **(1)**	<u>Example of equation</u> $Br_2(aq) + H_2O(l) \rightarrow HOBr(aq) + HBr(aq)$ Allow multiples Allow $H^+(aq) + Br^-(aq)$ for HBr(aq) Allow reversible arrows Ignore state symbols even if incorrect $E^{\ominus}_{cell} = 1.09 - 1.57 = -0.48$ (V) Allow correct answer without calculation Allow 3 marks for reverse argument $HOBr(aq) + HBr(aq) \rightarrow Br_2(aq) + H_2O(aq)$ (1) $E^{\ominus}_{cell} = 1.57 - 1.09 = (+) 0.48$ (V) (1) $E^{\ominus}_{cell}$ is positive / >0 so the reverse of disproportionation is (thermodynamically) feasible (1)	**(3)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following point: • disproportionation is an equilibrium system (and although K is very small, there is still a small concentration of disproportionation products) **or** excess water is used **or** concentration is not 1 mol dm^{-3} **or** HOBr undergoes further disproportionation	Ignore just 'non-standard conditions' Ignore references to activation energy / collision theory Ignore H^+ / ions from the water	**(1)**

Q7.

Question Number	Answer	Additional Guidance	Mark
(i)	• balanced equation	Example of equation $3Cl_2 + 6OH^- \rightarrow 5Cl^- + ClO_3^- + 3H_2O$ Allow multiples Ignore state symbols even if incorrect	(1)

Question Number	Answer	Additional Guidance	Mark
(ii) Clip with (i)	An explanation that makes reference to the following points: • oxidation number for chlorine changes from 0 to -1 so it is **reduced** **(1)** • oxidation number for chlorine changes from 0 to +5 so it is **oxidised** **(1)**	Ignore general definitions of disproportionation Accept oxidation numbers and their changes shown with equation Allow 1 out of 2 marks for three correct oxidation numbers of the chlorine	(2)

Q8.

Question Number	Acceptable Answer	Additional Guidance	Mark
	ClO_3^- **(1)** (Cl is) +5 / 5+ **(1)**	Allow $NaClO_3$ / $KClO_3$ Allow (+)V Do not award 5 unless +5/5+ seen in the formula or as a label on the formula	(2)

Q9.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points:	Allow the oxidation numbers written by the species in the table (+)6 only needs to be mentioned once in M1 or M2 Allow references to potassium halides / halogens / hydrogen halides instead of halide ions For full marks, the answer must identify iodide as the strongest reducing agent	**(3)**
	• iodide ions are the strongest reducing agent because iodide ions / I^- / (potassium) iodide reduces sulfur (in sulfuric acid) from +6 to 0 in sulfur / −2 in H_2S **(1)**	Only 1 oxidation number change is needed. If both are given, both must be correct	
	• (whereas) bromide ions / Br^- / (potassium) bromide reduces sulfur (in sulfuric acid) from +6 to +4 **(1)**	Allow bromide ions are stronger reducing agents than chloride ions because they are oxidised from −1 to 0	
	• (whereas) chloride ions / Cl^- / (potassium) chloride do not reduce sulfuric acid / sulfur / S (as there is no change in oxidation number of Cl or S) **(1)**	Allow just 'it is not a redox reaction'	

Q10.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following points: • the covalent bond in hydrogen chloride changes to an ionic bond in aqueous solution	Both types of bond required Accept covalent bond breaks, ions are formed Accept $HCl(g) \rightarrow H^+(aq) + Cl^-(aq)$ or $HCl(g) + H_2O(l) \rightarrow H_3O^+(aq) + Cl^-(aq)$	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	• correct species on each side of equation **(1)** • correct states for all species **(1)**	Example of equation: $HCl(g) + NH_3(g) \rightarrow NH_4Cl(s)$ / $NH_4^+Cl^-(s)$ / $NH_4^+(s) + Cl^-(s)$ Allow (aq) or (g) for reactants Do not award (liquid) for either reactant Two products will lose both marks	(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to the following points: • first observation **(1)** • second observation **(1)**	Allow observations in any order Sodium carbonate/Na_2CO_3/(white) solid dissolves/disappears/forms a colourless solution Effervescence/fizzing/bubbles Ignore gas/carbon dioxide given off Do not award if any named gas other than carbon dioxide, eg hydrogen or oxygen	(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(iv)	A description that makes reference to the following points: • remove a fixed amount of one solution using a pipette into a conical flask and fill up the burette with other solution **(1)** • add a named indicator **and** colour change **(1)** • add solution from burette to flask until indicator changes colour **(1)** • technique mark **(1)** • repeat titrations (until concordant results obtained) **(1)**	Allow use of any suitable flask in place of conical flask. Allow any recognised acid/base indicator: methyl red / orange, phenolphthalein etc. Ignore litmus /UI. Do not award reversed colour change Do not penalise reverse colour change again here. Any one from: Rinsing burette/pipette with appropriate solution, use of white tile, adding slowly, swirling flask etc. Ignore mention of 'rough' or 'trial' runs etc	**(5)**

Q11.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An answer that makes reference to the following points: • ammonium **(1)** • bromide **(1)**	Mark independently Allow names in either order Ignore symbols as well as names Do not award ammonia Do not award bromine Allow (1) for just NH_4Br	**(2)**

Q12.

Question Number	Acceptable Answers	Additional Guidance	Mark
	• correct equation	Example of equation $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$ Allow multiples Allow Na^+ on both sides if crossed through Ignore state symbols even if incorrect	**(1)**

Q13.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	$Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$	Allow multiples Ignore state symbols even if incorrect	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following points: • chlorine/bromine toxic/poisonous **(1)** • (Carry out the experiment in a) fume cupboard **(1)** OR • bromine corrosive **(1)** • wear gloves **(1)**	2nd mark dependent on first. Do not award harmful, but allow MP2 if correct for toxic.	**(2)**

Q14.

Question Number	Answer	Additional Guidance	Mark
(i)	• ionic equation (1) • state symbols (1)	Example of equation $Ag^+(aq) + I^-(aq) \rightarrow AgI(s)$ Allow multiples M2 dependent on M1 or near miss	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that includes • halide ion with some justification attempt (1) • calculation of expected mass of silver halides (1)	Incorrect halide scores (0) Bromide (ion)/Br^- Do not award 'bromine (ion)' 0.01 mol of AgCl = 1.43 (g) AgBr = 1.88 (g) AgI = 2.35 (g) OR Mass of 1.0 mol is 188 g so subtraction of 107.9 for Ag means X = 80.1 so closest is Br TE on incorrect formula silver halide in d(i)	(2)

Q15.

Question Number	Answer	Additional Guidance	Mark
(i)	• (The cation in **X** is) Fe^{2+} / iron(II) / Fe(II) (1) • (The anion in **X** is) SO_4^{2-} / sulfate(VI) (1)	Allow Fe^{+2} Allow sulfate / SO_4^{-2} Do not award sulfite / sulfate(IV)	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	• species and balancing (1) • state symbols (1)	Examples of equation $Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$ **or** $[Fe(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s) + 6H_2O(l)$ **or** $[Fe(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(H_2O)_4(s) + 2H_2O(l)$ Ignore missing square brackets TE on cation that forms an insoluble hydroxide in **Test 1** State symbols conditional on correct species or 'near miss' / non-ionic equation	(2)

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to the following point: • Fe^{2+} is oxidised (to Fe^{3+}) by oxygen / air	Allow iron(III) hydroxide / iron(III) (ions) are formed by reaction with oxygen / air TE on cation in **Test 1** Allow just 'the precipitate / it is oxidised by oxygen / air'	(1)

Question Number	Answer	Additional Guidance	Mark
(iv)	An answer that makes reference to the following point: • to react with / remove any carbonate / sulfite / sulfate(IV) ions **or** to eliminate the possibility of carbonate / sulfite / sulfate(IV) ions	Allow to prevent any other ions forming a precipitate with barium ions / Ba^{2+}	(1)

Q16.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	$Cl_2 + 2e^{(-)} \rightarrow 2Cl^-$	Allow multiples Ignore state symbols even if incorrect	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	$Cl_2 + 4OH^- \rightarrow 2ClO^- + 2H_2O + 2e^{(-)}$	Allow multiples $Cl_2 + 2OH^- \rightarrow 2ClO^- + 2H^+ + 2e^{(-)}$ Ignore state symbols even if incorrect	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	$Cl_2 + 2OH^- \rightarrow Cl^- + ClO^- + H_2O$	Allow multiples Ignore state symbols even if incorrect Do not award mark if electrons are un-cancelled	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(iv)	An explanation that makes reference to the following points: • (disproportionation is simultaneous) oxidation and reduction of an element (in the same species) **(1)** • chlorine changes from 0 to -1 **and** +1 **(1)**	 Allow statement that chlorine is oxidised **and** reduced This can be shown on the equation in (iii)	**(2)**

Q17.

Question Number	Acceptable Answers	Additional Guidance	Mark
(i)	An answer that makes reference to the following points: **setting up of the dipole** • uneven distribution of **electrons**/ (random) movement of **electrons** / (random) fluctuations of **electrons** **(1)** **type of dipole** • (results in an) instantaneous dipole / temporary dipole (in the first molecule) **(1)** **induction of a second dipole** • causes/induces a (second) dipole on another molecule **(1)**	M1 & M3 could be scored for an appropriate diagram Allow "Change in **electron** density" Allow "transient dipole" / "oscillating dipole" Do not award for "permanent dipole" Allow neighbouring molecule / adjacent molecule Do not award for "permanent dipole"	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following points: **relative number of electrons** • bromine has more **electrons** (than chlorine) / bromine has one more shell of **electrons** (than chlorine) **(1)** **relative strength of intermolecular forces** • (so) bromine has stronger (London) forces (between molecules) / more (heat) energy is needed to overcome the London forces between bromine molecules / greater temporary dipole – induced dipole forces **(1)**	Allow reverse arguments Allow correct formulae Bromine has 35/70 electrons and chlorine has 17/34 electrons Ignore comments about protons, molecular mass etc Do not award "more outer shells" Ignore comments about 'points of contact' Allow more (London) forces Allow "bonds between molecules" Award **(0)** marks overall if any implication that **covalent** bonds are broken (on boiling)	**(2)**

Q18.

Question Number	Acceptable Answers	Additional Guidance	Mark
(i)	**Test 1** • (gas is) ammonia / NH_3 **(1)** • (cation is) ammonium / NH_4^+ **(1)** **Test 2** • (cation is) cobalt(II) / Co^{2+} / $[Co(H_2O)_6]^{2+}$ **(1)** • (complex ion is) $[CoCl_4]^{2-}$ **(1)** **Test 3** • (precipitate is) barium sulfate / $BaSO_4$ **(1)** • (anion is) sulfate((VI)) / SO_4^{2-} **(1)**	If name and formula are given, both must be correct Mark independently Do not award gas is ammonium / NH_4 Do not award cation is ammonia / NH_3^+ Oxidation number of cobalt is needed in the name but allow cobalt **with** Co^{2+} Charge is needed on the ion Allow +2 and −2 for the charges on the ions Allow brackets around Cl Ignore missing square brackets in complex ions Do not award $[CoCl_6]^{4-}$ **Note** If cation in Test 2 is identified as copper(II) / Cu^{2+}, do not award M3 but M4 can be awarded as TE for $[CuCl_4]^{2-}$ Oxidation number of sulfate is not needed but if given must be correct e.g. do not award sulfate(IV)	**(6)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(ii)	• correct formula	<u>Examples of correct formula</u> $(NH_4)_2Co(SO_4)_2$ $(NH_4)_2SO_4.CoSO_4$ Allow NH_4, Co and SO_4 in any order Allow multiples Allow any combination of Co^{2+} / NH_4^+ / SO_4^{2-} that gives a neutral complex TE on the **three** ions identified in (a)(i) Ignore missing dot in second formula Ignore any amount of water of crystallisation	**(1)**

Q19.

Question Number	Acceptable Answers	Additional Guidance	Mark
	An answer that makes reference to the following points: **mixing of 1st pair of solutions** • mix Br_2 with KCl **(1)** **mixing of 2nd pair of solutions** • mix Br_2 with KI **or** mix I_2 with KBr **(1)** **colours of halogen (in cyclohexane)** • colour seen for experiment 1/ bromine is orange / yellow **and** colour seen for experiment 2/ iodine is purple / pink / violet / lilac **(1)** **correct ionic equation** • $Br_2 + 2I^- \rightarrow 2Br^- + I_2$ **(1)** **(1)** • use of ONLY two correct experiments as above **(1)**	Ignore any reference to any additional reactions, e.g. with silver nitrate Award mark if correct ionic equation is given Ignore colours before the addition of cyclohexane Do not award brown Do not award red Allow multiples Ignore state symbols even if incorrect	**(5)**

Q20.

Question Number	Answer	Additional Guidance	Mark
(i)	• chlorine is oxidised **and** from 0 to +1 (in NaClO) (1) • chlorine is reduced **and** from 0 to -1 (in NaCl) (1)	Check the equation Allow (1) for three correct oxidation numbers if no other mark is awarded. Allow (1) max for general definition of disproportionation	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	• equation	$6\,NaOH + 3\,Cl_2 \rightarrow NaClO_3 + 5\,NaCl + 3\,H_2O$ Allow multiples	(1)

Question Number	Answer	Mark
(iii)	**The only correct answer is C** (hot alkali) **A** *is not correct because high temperature is required* **B** *is not correct because high temperature is required* **D** *is not correct because high temperature and not excess chlorine is required*	(1)

Q21.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following points: • chlorine / Cl_2 is simultaneously oxidised and reduced (1) • the oxidation number of chlorine changes from 0 to –I and (+)I / 0 to –1 and (+)1 / increases by 1 and decreases by 1 (1)	Allow oxidation numbers underneath or above the equation	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	• substances correct in equation (1) • equation is balanced (1)	<u>Example of equation</u> $3Cl_2 + 6NaOH \rightarrow NaClO_3 + 5NaCl + 3H_2O$ Ignore state symbols even if incorrect	(2)

Q22.

Question Number	Acceptable Answers	Additional Guidance	Mark
(i)	• chlorine is a gas **and** iodine is a solid	Ignore any colours, even if incorrect Do not award reference to ions once in (i)/(ii) Allow use of Cl and I	(1)
(ii)	• astatine is a solid **and** (as the number of electrons increases) the strength of the London forces increases / more London forces	Allow for 'London forces' instantaneous dipole – induced dipole / van der Waals' forces / dispersion forces / induced dipole forces / temporary dipole Ignore ID-ID References to stability The trend is increasing melting (and boiling) temperature down the group	(1)

Q23.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following points. • cool (the reaction mixture) **(1)** • filter off (the less soluble potassium iodate) **(1)** • any suitable method of drying (the resulting solid) **(1)**	Mark independently Ignore addition of extra water Allow give time for potassium iodate to crystallise Ignore the method used to cool the solution, (ice, fridge etc.) Ignore any details of the filtration methods Examples of methods used to dry: 'leave to dry', warm oven, press between filter papers	(3)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following points: • add silver nitrate (solution) / $AgNO_3$ (and HNO_3 / nitric acid) **(1)** • yellow **and** precipitate /ppt/solid/crystals **(1)**	Mark independently Do not award hydrochloric acid Allow a correct description of the yellow ppt, e.g. primrose coloured Do not award 'electrolysis'	**(2)**

Q24.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to: • addition of (dilute/strong) name/formula of acid **(1)** • effervescence/bubbling/fizzing **(1)**	 Allow weak acids If formula given then must be correct Allow Gas given off which turns limewater cloudy Do not award just 'gas/ CO_2 given off' Do not award incorrect observations such as precipitate forming due to addition of acid M2 dependent on M1 or 'near miss'	**(2)**

Q25.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to: • addition of barium chloride/nitrate (solution) **(1)** • white precipitate forms **(1)**	 Accept formulae $BaCl_2$/$Ba(NO_3)_2$ Ignore addition of acids such as HCl or HNO_3 but do not award M1 if addition of sulfuric acid Allow white solid If ppt identified then must be correct M2 dependent on M1 or 'near miss'	**(2)**

Q26.

Question Number	Acceptable Answers	Additional Guidance	Mark
	$Cl_2 + 2NaOH \rightarrow NaCl + NaClO + H_2O$ **(1)** • (Type of reaction) disproportionation **(1)**	Accept multiples and ionic equations. Allow NaOCl $Cl_2 + 2OH^- \rightarrow Cl^- + ClO^- + H_2O$ Ignore state symbols even if incorrect Ignore redox Mark independently	**(2)**

Q27.

Question Number	Answer	Mark
(i)	**The only correct answer is C** (Disproportionation) ***A** is not correct because oxidation and reduction are occurring* ***B** is not correct because oxidation and reduction are occurring* ***D** is not correct because two reactants are involved*	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following points: • (trigonal) pyramidal **(1)** • (predicted bond angle) 107° **(1)** • three groups / three pairs of bonding electrons and one lone pair **OR** lone pair – bond pair repulsion > bond pair – bond pair repulsion **(1)** • (electron pairs / groups repel to positions of) minimum repulsion / maximum separation **(1)**	For M1, this shape must be **named** Allow answers in the range 106.5° to 107.5° (allow actual value 110°) Allow M2 on an annotated diagram Allow 'regions' for 'groups' or 'pairs' Allow statements such as "lone pair repulsion greater than bond pair repulsion"	**(4)**

Q28.

Question Number	Answer	Mark
(i)	**The only correct answer is C** (redox) **A** *is not correct because chlorine is reduced and iodide is oxidised* **B** *is not correct because chlorine is reduced and iodide is oxidised* **D** *is not correct because different species are oxidised and reduced*	**(1)**

Question Number	Answer	Mark
(ii)	**The only correct answer is A** (pale yellow) **B** *is not correct because the question refers to the aqueous layer* **C** *is not correct because the question refers to the aqueous layer* **D** *is not correct because this would be the colour of Cl_2 (aq) in the absence of I_2 (aq)*	**(1)**

Q29.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following point: • the oxidation number / state does not change for any element	Accept there is no transfer of electrons	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following points: • (because) sulfur in sulfuric acid is reduced further by hydrogen iodide than hydrogen bromide (and hydrogen chloride) (1) • SO_2 / S(IV) produced in the reaction with HBr (1) • more negative oxidation states of sulfur / S / H_2S / S^{2-} are produced in the reaction with HI	Mark independently Allow potassium salt / halide ion for hydrogen halide May be shown in an equation, but ignore incorrect state symbols and/or balancing May be shown in an equation, but ignore incorrect state symbols and/or balancing	(3)

Q30.

Question Number	Answer	Additional Guidance	Mark
(i)	• equation	Example of equation $Cl_2 + 2KBr \rightarrow Br_2 + 2KCl$ Accept ionic equation $Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ Allow multiples Ignore state symbols even if incorrect	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following points: • **(M1)** the precipitate is a mixture of silver chloride and silver bromide **or** not all of the bromide ions were oxidised **(1)** • **(M2)** silver chloride/AgCl dissolves in dilute ammonia **(1)** • **(M3)** silver bromide/AgBr does not dissolve in dilute ammonia **(1)**	 Allow Some bromide ions are still present/bromide ions were in excess/both chloride and bromide ions are present Do not award references to Cl^- dissolving Silver bromide only dissolves in concentrated ammonia	**(3)**

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to the following point: • iodine is a weaker oxidising agent than chlorine **or** iodine cannot oxidise bromide ions **or** iodine is a stronger reducing agent	 Accept reverse arguments Ignore Just references to reactivity/displacement e.g. iodine is less reactive/cannot displace	**(1)**

Q31.

Question Number	Answer		Mark
(i)	• silver nitrate (solution) / chlorine	Allow correct formula/$AgNO_3$ If both name and formula are given both must be correct Allow acidified silver nitrate (solution) Ignore addition of nitric acid Do not award sulfuric acid / hydrochloric acid Do not award conc. sulfuric acid here but allow TE in dii	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
	An answer that makes reference to the following points: • cream/off-white precipitate **(1)** • AgBr **(1)**	Do not accept just 'white' or 'yellow' Accept (very) pale yellow Ignore name Ignore unbalanced equation Award (2) marks for use of chlorine: orange / brown fumes / solution Br_2 (gas / aq) Allow TE (2) marks for use of conc. sulfuric acid in 3di choking fumes SO_2 (g)	**(2)**