1 Chlorine is an important industrial chemical.

(a) Chlorine is formed when $KMnO_4$ reacts with hydrochloric acid.
The ionic equation for this redox reaction is

$$16H^+ + 2MnO_4^- + 10Cl^- \longrightarrow 2Mn^{2+} + 8H_2O + 5Cl_2$$

(i) Deduce the half-equation for the oxidation of chloride ions to chlorine.

.....

(1)

(ii) Give the oxidation state of manganese in the MnO_4^- ion.

.....

(1)

(iii) Deduce the half-equation for the reduction of the MnO_4^- ions in acidified solution to manganese(II) ions and water.

.....

(1)

(b) Chlorine behaves as an oxidising agent in the extraction of bromine from seawater.
In this process, chlorine gas is bubbled through a solution containing bromide ions.

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

.....

(1)

(ii) Give **one** observation that would be made during this reaction.

.....

.....

(1)

(iii) In terms of electrons, state the meaning of the term **oxidising agent**.

.....

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(1)

(c) In sunlight, chlorine can also oxidise water slowly to form oxygen.

Write an equation for this reaction.
Give the oxidation state of chlorine in the chlorine-containing species that is formed.

Equation

.....

Oxidation state of chlorine in the species formed .....

(2)

(d) Explain why chlorine has a lower boiling point than bromine.

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(2)
(Total 10 marks)

2 The following pairs of compounds can be distinguished by simple test−tube reactions.

For each pair of compounds, give a reagent (or combination of reagents) that, when added separately to each compound, could be used to distinguish between them.
State what is observed in each case.

(a) Butan−2−ol and 2−methylpropan−2−ol

Reagent .....

Observation with butan−2−ol

.....

.....

Observation with 2−methylpropan−2−ol

.....

.....

(3)

(b) Propane and propene

Reagent .....

Observation with propane

.....

.....

Observation with propene

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(3)

(c) Aqueous silver nitrate and aqueous sodium nitrate

Reagent .....

Observation with aqueous silver nitrate

.....

.....

Observation with aqueous sodium nitrate

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.....

(3)

(d) Aqueous magnesium chloride and aqueous barium chloride

Reagent .....

Observation with aqueous magnesium chloride

.....

.....

Observation with aqueous barium chloride

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(3)
(Total 12 marks)

3 For many years, swimming pool water has been treated with chlorine gas. The chlorine is added to kill any harmful bacteria unintentionally introduced by swimmers. Pool managers are required to check that the chlorine concentration is high enough to kill the bacteria without being a health hazard to the swimmers.

When chlorine reacts with water in the absence of sunlight, the chlorine is both oxidised and reduced and an equilibrium is established.

(a) Write an equation for this equilibrium.

For each chlorine-containing species in the equation, write the oxidation state of chlorine below the species.

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(2)

(b) The pool manager maintains the water at a pH slightly greater than 7.0

Explain how this affects the equilibrium established when chlorine is added to water.

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(2)

(c) Explain why chlorine is used to kill bacteria in swimming pools, even though chlorine is toxic.

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(2)

(Total 6 marks)

4 This question is about the chemical properties of chlorine, sodium chloride and sodium bromide.

(a) Sodium bromide reacts with concentrated sulfuric acid in a different way from sodium chloride.

Write an equation for this reaction of sodium bromide and explain why bromide ions react differently from chloride ions.

Equation .....

Explanation .....

.....

.....

.....

(3)

(b) A colourless solution contains a mixture of sodium chloride and sodium bromide.

Using aqueous silver nitrate and any other reagents of your choice, develop a procedure to prepare a pure sample of silver bromide from this mixture.
Explain each step in the procedure and illustrate your explanations with equations, where appropriate.

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(6)

(c) Write an ionic equation for the reaction between chlorine and cold dilute sodium hydroxide solution.
Give the oxidation state of chlorine in each of the chlorine-containing ions formed.

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(2)
(Total 11 marks)

5 Which of these species is the best reducing agent?

A Cl_2 ⬭

B Cl^- ⬭

C I_2 ⬭

D I^- ⬭

(Total 1 mark)

6 Which of these substances reacts most rapidly to produce a silver halide precipitate with acidified silver nitrate?

A CH_3Br ⬭

B CH_3Cl ⬭

C CH_3F ⬭

D CH_3I ⬭

(Total 1 mark)

7 The table below shows observations of changes from some test-tube reactions of aqueous solutions of compounds **Q**, **R** and **S** with five different aqueous reagents. The initial colours of the solutions are not given.

	$BaCl_2$ + HCl	**$AgNO_3$ + HNO_3**	**NaOH**	**Na_2CO_3**	**HCl (conc)**
Q	no change observed	pale cream precipitate	white precipitate	white precipitate	no change observed
R	no change observd	white precipitate	white precipitate, dissolves in excess of NaOH	white precipitate, bubbles of a gas	no change observed
S	white precipitate	no change observed	brown precipitate	brown precipitate, bubbles of a gas	yellow solution

(a) Identify each of compounds **Q**, **R** and **S**.
You are **not** required to explain your answers.

Identity of **Q** .....

.....

Identity of **R** .....

.....

Identity of **S** .....

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(6)

(b) Write ionic equations for each of the positive observations with **S**.

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(4)
(Total 10 marks)

8 This question is about Group 7 chemistry.

(a) Sea water is a major source of iodine.
The iodine extracted from sea water is impure. It is purified in a two-stage process.

Stage **1** $I_2 + 2H_2O + SO_2 \longrightarrow 2HI + H_2SO_4$

Stage **2** $2HI + Cl_2 \longrightarrow I_2 + 2HCl$

(i) State the initial oxidation state and the final oxidation state of sulfur in Stage **1**.

Oxidation state of S in SO_2 .....

Oxidation state of S in H_2SO_4 .....

(2)

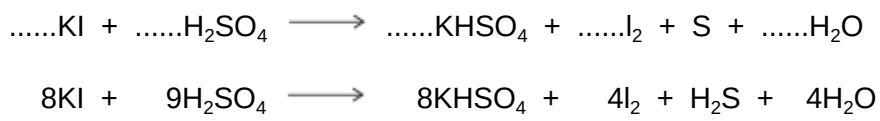
(ii) State, in terms of electrons, what has happened to chlorine in Stage **2**.

.....

.....

(1)

(b) When concentrated sulfuric acid is added to potassium iodide, iodine is formed in the following redox equations.



(i) Balance the equation for the reaction that forms sulfur.

(1)

(ii) Deduce the half-equation for the formation of iodine from iodide ions.

.....

(1)

(iii) Deduce the half-equation for the formation of hydrogen sulfide from concentrated sulfuric acid.

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(1)

(c) A yellow precipitate is formed when silver nitrate solution, acidified with dilute nitric acid, is added to an aqueous solution containing iodide ions.

(i) Write the **simplest ionic** equation for the formation of the yellow precipitate.

.....

(1)

(ii) State what is observed when concentrated ammonia solution is added to this yellow precipitate.

.....

.....

(1)

(iii) State why the silver nitrate solution is acidified when testing for iodide ions.

.....

.....

.....

(1)

(iv) Explain why dilute hydrochloric acid is **not** used to acidify the silver nitrate solution in this test for iodide ions.

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(1)

(d) Chlorine is toxic to humans. This toxicity does not prevent the large-scale use of chlorine in water treatment.

(i) Give **one** reason why water is treated with chlorine.

.....

.....

(1)

(ii) Explain why the toxicity of chlorine does **not** prevent this use.

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.....

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(1)

(iii) Write an equation for the reaction of chlorine with cold water.

.....

(1)

(e) Give the formulas of the **two** different chlorine-containing compounds that are formed when chlorine reacts with cold, dilute, aqueous sodium hydroxide.

Formula 1 .....

Formula 2 .....

(1)

(Total 14 marks)

9 (a) Strontium chloride is used in toothpaste for sensitive teeth.
Both strontium carbonate and strontium sulfate are white solids that are insoluble in water.

(i) Write an equation for the reaction between strontium chloride solution and sodium sulfate solution.
Include state symbols in your equation.

.....

(1)

(ii) Strontium carbonate reacts with nitric acid to produce a solution of strontium nitrate. Strontium sulfate does not react with nitric acid.

Describe briefly how you could obtain strontium sulfate from a mixture of strontium carbonate and strontium sulfate.
You are **not** required to describe the purification of the strontium sulfate.

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(2)

(b) A solution of magnesium sulfate is sometimes given as first aid to someone who has swallowed barium chloride.

Explain why drinking magnesium sulfate solution is effective in the treatment of barium poisoning.

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(1)

(c) Medicines for the treatment of nervous disorders often contain calcium bromide.
Silver nitrate, acidified with dilute nitric acid, can be used together with another reagent to test for the presence of bromide ions in a solution of a medicine.

Describe briefly how you would carry out this test and state what you would observe.

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(3)
(Total 7 marks)

10 (a) Anhydrous strontium chloride is not used in toothpaste because it absorbs water from the atmosphere. The hexahydrate, $SrCl_2.6H_2O$, is preferred.

A chemist was asked to determine the purity of a sample of strontium chloride hexahydrate. The chemist weighed out 2.25 g of the sample and added it to 100 cm^3 of water. The mixture was warmed and stirred for several minutes to dissolve all of the strontium chloride in the sample. The mixture was then filtered into a conical flask. An excess of silver nitrate solution was added to the flask and the contents swirled for 1 minute to make sure that the precipitation was complete.

The silver chloride precipitate was separated from the mixture by filtration. The precipitate was washed several times with deionised water and dried carefully. The chemist weighed the dry precipitate and recorded a mass of 1.55 g.

(i) Calculate the amount, in moles, of AgCl in 1.55 g of silver chloride (M_r = 143.4).

.....

(1)

(ii) The equation for the reaction between strontium chloride and silver nitrate is

$$SrCl_2 + 2AgNO_3 \longrightarrow 2AgCl + Sr(NO_3)_2$$

Use your answer from part (i) and this equation to calculate the amount, in moles, of $SrCl_2$ needed to form 1.55 g of silver chloride.

.....

.....

(1)

(iii) Use data from the Periodic Table to calculate the M_r of strontium chloride hexahydrate. Give your answer to 1 decimal place.

.....

.....

(1)

(iv) Use your answers from parts (a)(ii) and (a)(iii) to calculate the percentage by mass of strontium chloride hexahydrate in the sample. Show your working.
Give your answer to the appropriate precision.

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(2)

(v) Several steps in the practical procedure were designed to ensure an accurate value for the percentage by mass of strontium chloride hexahydrate in the sample.

1 Explain why the solution of strontium chloride was filtered to remove insoluble impurities before the addition of silver nitrate.

.....

.....

(1)

2 Explain why the precipitate of silver chloride was washed several times with deionised water.

.....

.....

(1)

(b) Magnesium hydroxide and magnesium carbonate are used to reduce acidity in the stomach. Magnesium hydroxide can be prepared by the reaction of solutions of magnesium chloride and sodium hydroxide.

(i) Write the **simplest ionic** equation for the reaction that occurs between magnesium chloride and sodium hydroxide.
Include state symbols in your equation.

.....

(1)

(ii) Other than cost, explain one advantage of using magnesium hydroxide rather than magnesium carbonate to reduce acidity in the stomach.

.....

.....

(1)

(c) Calcium ethanoate, $(CH_3COO)_2Ca$, is used in the treatment of kidney disease.
Thermal decomposition of calcium ethanoate under certain conditions gives propanone and **one** other product.

Write an equation for the thermal decomposition of calcium ethanoate.

.....

(1)

(d) Salts containing the chromate(VI) ion are usually yellow in colour.
Calcium chromate(VI) is soluble in water.
Strontium chromate(VI) is insoluble in water, but will dissolve in a solution of ethanoic acid.
Barium chromate(VI) is insoluble in water and is also insoluble in a solution of ethanoic acid.

Describe a series of tests using solutions of sodium chromate(VI) and ethanoic acid that would allow you to distinguish between separate solutions of calcium chloride, strontium chloride and barium chloride.
State what you would observe in each test.

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(3)

(e) The strontium salt of ranelic acid is used to promote bone growth. Analysis of a pure sample of ranelic acid showed that it contained 42.09% of carbon, 2.92% of hydrogen, 8.18% of nitrogen, 37.42% of oxygen and 9.39% of sulfur by mass.

Use these data to calculate the empirical formula of ranelic acid.
Show your working.

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(2)
(Total 15 marks)

11 The following pairs of compounds can be distinguished by simple test-tube reactions.

For each pair, give a suitable reagent that could be added separately to each compound to distinguish between them.
Describe what you would observe in each case.

(a) AgBr(s) and AgI(s)

Reagent .....

Observation with AgBr(s).....

.....

Observation with AgI(s) .....

.....

(3)

(b) HCl(aq) and HNO_3(aq)

Reagent .....

Observation with HCl(aq) .....

.....

Observation with HNO_3(aq) .....

.....

(3)

(c) Cyclohexane and cyclohexene

Reagent .....

Observation with cyclohexane .....

.....

Observation with cyclohexene .....

.....

(3)

(d) Butanal and butanone

Reagent .....

Observation with butanal .....

.....

Observation with butanone .....

.....

(3)
(Total 12 marks)

12 (a) Chlorine displaces iodine from aqueous potassium iodide.

(i) Write the **simplest ionic** equation for this reaction.

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(1)

(ii) Give **one** observation that you would make when this reaction occurs.

.....

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(1)

(b) In bright sunlight, chlorine reacts with water to form oxygen as one of the products.
Write an equation for this reaction.

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(1)

(c) Explain why chlorine has a lower boiling point than bromine.

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(Extra space) .....

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(2)
(Total 5 marks)

13 Aldehydes can be prepared from acyl chlorides.

State how an aldehyde could be tested to show whether it is contaminated with traces of unreacted acyl chloride.
State what you would observe.

Test .....

Observation .....

.....

(Total 2 marks)

14 Concentrated sulfuric acid reacts with solid potassium iodide as shown in the equation.

$$8KI + 9H_2SO_4 \longrightarrow 4I_2 + 8KHSO_4 + H_2S + 4H_2O$$

Give **two** observations that you would make when this reaction occurs.

In terms of electrons, state what happens to the iodide ions in this reaction.

State the **change** in oxidation state of sulfur that occurs during this formation of H_2S and deduce the half-equation for the conversion of H_2SO_4 into H_2S

(Total 5 marks)

15 Chlorine is a powerful oxidising agent.

(a) Write the **simplest ionic** equation for the reaction between chlorine and aqueous potassium bromide.

State what is observed when this reaction occurs.

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(Extra space) .....

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(2)

(b) Write an equation for the reaction between chlorine and cold, dilute, aqueous sodium hydroxide.

Give a major use for the solution that is formed by this reaction.

Give the IUPAC name of the chlorine-containing compound formed in this reaction in which chlorine has an oxidation state of +1.

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(Extra space) .....

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(3)

(c) Write an equation for the equilibrium reaction that occurs when chlorine gas reacts with cold water.

Give **one** reason why chlorine is used for the treatment of drinking water even though the gas is very toxic.

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(Extra space) .....

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(2)

(d) State how you could test a sample of water to show that it contains chloride ions.

In your answer, give a reagent, **one** observation and the **simplest ionic** equation for the reaction with the reagent.

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(Extra space) .....

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(3)
(Total 10 marks)

16 A student investigated the chemistry of the halogens and the halide ions.

(a) In the first two tests, the student made the following observations.

Test	Observation
1. Add chlorine water to aqueous potassium iodide solution.	The colourless solution turned a brown colour.
2. Add silver nitrate solution to aqueous potassium chloride solution.	The colourless solution produced a white precipitate.

(i) Identify the species responsible for the brown colour in Test **1**.

Write the **simplest ionic** equation for the reaction that has taken place in Test **1**.

State the type of reaction that has taken place in Test **1**.

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(Extra space) .....

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(3)

(ii) Name the species responsible for the white precipitate in Test **2**.

Write the **simplest ionic** equation for the reaction that has taken place in Test **2**.

State what would be observed when an excess of dilute ammonia solution is added to the white precipitate obtained in Test **2**.

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(Extra space) .....

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(3)

(b) In two further tests, the student made the following observations.

Test	Observation
3. Add concentrated sulfuric acid to solid potassium chloride.	The white solid produced misty white fumes which turned blue litmus paper to red.
4. Add concentrated sulfuric acid to solid potassium iodide.	The white solid turned black. A gas was released that smelled of rotten eggs. A yellow solid was formed.

(i) Write the **simplest ionic** equation for the reaction that has taken place in Test **3**.

Identify the species responsible for the misty white fumes produced in Test **3**.

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.....

(Extra space) .....

.....

(2)

(ii) The student had read in a textbook that the equation for one of the reactions in Test **4** is as follows.

$$8H^+ + 8I^- + H_2SO_4 \longrightarrow 4I_2 + H_2S + 4H_2O$$

Write the **two** half-equations for this reaction.

State the role of the sulfuric acid and identify the yellow solid that is also observed in Test **4**.

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(Extra space) .....

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(4)

(iii) The student knew that bromine can be used for killing microorganisms in swimming pool water.
The following equilibrium is established when bromine is added to cold water.

$$Br_2(l) + H_2O(l) \rightleftharpoons HBrO(aq) + H^+(aq) + Br^-(aq)$$

Use Le Chatelier's principle to explain why this equilibrium moves to the right when sodium hydroxide solution is added to a solution containing dissolved bromine.

Deduce why bromine can be used for killing microorganisms in swimming pool water, even though bromine is toxic.

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(Extra space) .....

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(3)
(Total 15 marks)

17 Iodine reacts with concentrated nitric acid to produce nitrogen dioxide (NO_2).

(a) (i) Give the oxidation state of iodine in each of the following.

I_2 .....

HIO_3.....

(2)

(ii) Complete the balancing of the following equation.

$I_2 + 10HNO_3 \longrightarrow$ .....HIO_3 + ...NO_2 + ...H_2O

(1)

(b) In industry, iodine is produced from the $NaIO_3$ that remains after sodium nitrate has been crystallised from the mineral Chile saltpetre.
The final stage involves the reaction between $NaIO_3$ and NaI in acidic solution.
Half-equations for the redox processes are given below.

$$IO_3^- + 5e^- + 6H^+ \longrightarrow 3H_2O + \frac{1}{2}I_2$$

$$I^- \longrightarrow \frac{1}{2}I_2 + e^-$$

Use these half-equations to deduce an overall ionic equation for the production of iodine by this process. Identify the oxidising agent.

Overall ionic equation

The oxidising agent .....

(2)

(c) When concentrated sulfuric acid is added to potassium iodide, solid sulfur and a black solid are formed.

(i) Identify the black solid.

.....

(1)

(ii) Deduce the half-equation for the formation of sulfur from concentrated sulfuric acid.

.....

(1)

(d) When iodide ions react with concentrated sulfuric acid in a different redox reaction, the oxidation state of sulfur changes from +6 to -2. The reduction product of this reaction is a poisonous gas that has an unpleasant smell.
Identify this gas.

.....

(1)

(e) A yellow precipitate is formed when silver nitrate solution, acidified with dilute nitric acid, is added to an aqueous solution containing iodide ions.

(ii) Write the **simplest ionic** equation for the formation of the yellow precipitate.

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(1)

(ii) State what is observed when concentrated ammonia solution is added to this precipitate.

.....

.....

(1)

(iii) State why the silver nitrate is acidified when testing for iodide ions.

.....

.....

(1)

(f) Consider the following reaction in which iodide ions behave as reducing agents.

$$Cl_2(aq) + 2I^-(aq) \longrightarrow I_2(aq) + 2Cl^-(aq)$$

(i) In terms of electrons, state the meaning of the term *reducing agent*.

.....

.....

(1)

(ii) Write a half-equation for the conversion of chlorine into chloride ions.

.....

(1)

(iii) Suggest why iodide ions are stronger reducing agents than chloride ions.

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(Extra space) .....

.....

(2)

(Total 15 marks)

18 Fluorine and iodine are elements in Group 7 of the Periodic Table.

(a) Explain why iodine has a higher melting point than fluorine.

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(Extra space).....

.....

(2)

(b) (i) Draw the shape of the NHF_2 molecule and the shape of the BF_3 molecule.

Include any lone pairs of electrons that influence the shape. In each case name the shape.

Shape of NHF_2 Shape of BF_3

Name of shape of NHF_2 .....

Name of shape of BF_3 .....

(4)

(ii) Suggest a value for the F—N—F bond angle in NH_2I

.....

(1)

(c) State the strongest type of intermolecular force in a sample of NHF_2

.....

(1)

(d) A molecule of NHF_2 reacts with a molecule of BF_3 as shown in the following equation.

$$NHF_2 + BF_3 \longrightarrow F_2HNBF_3$$

State the type of bond formed between the N atom and the B atom in F_2HNBF_3.

Explain how this bond is formed.

Name of type of bond .....

How bond is formed .....

.....

.....

(2)

(Total 10 marks)

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

.....

(1)

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

.....

(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**.

.....

(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.

.....

(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)

20 (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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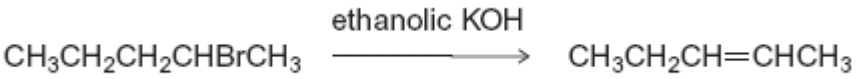
(5)
(Total 15 marks)

21 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)

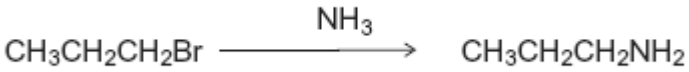
(ii) Draw the structure of the other structurally isomeric alkene produced when 2-bromopentane reacts with ethanolic KOH.

(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)

22 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 .....

.....

Equation .....

(2)

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

.....

(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 .....

.....

(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.

.....

(1)
(Total 10 marks)

23 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.

.....

.....

(1)

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

.....

.....

.....

(2)
(Total 3 marks)

24 (a) Propanoic acid can be made from propan-1-ol by oxidation using acidified potassium dichromate(VI). Propanal is formed as an intermediate during this oxidation.

(i) State the colour of the chromium species after the potassium dichromate(VI) has reacted.

.....

(1)

(ii) Describe the experimental conditions and the practical method used to ensure that the acid is obtained in a high yield. Draw a diagram of the assembled apparatus you would use.

Conditions .....

.....

Apparatus

(4)

(iii) Describe the different experimental conditions necessary to produce propanal in high yield rather than propanoic acid.

.....

.....

(2)

(b) Propan-1-ol is a volatile, flammable liquid.
Give **one** safety precaution that should be used during the reaction to minimise this hazard.

.....

(1)

(c) A student followed the progress of the oxidation of propan-1-ol to propanoic acid by extracting the organic compounds from one sample of reaction mixture.

(i) Give a chemical reagent which would enable the student to confirm the presence of propanal in the extracted compounds.
State what you would observe when propanal reacts with this reagent.

Reagent .....

Observation .....

.....

(2)

(ii) Give a chemical reagent that would enable the student to confirm the presence of propanoic acid in the extracted compounds.
State what you would observe when propanoic acid reacts with this reagent.

Reagent .....

Observation .....

.....

(2)

(d) Predict which **one** of the compounds, propan-1-ol, propanal and propanoic acid will have the highest boiling point. Explain your answer.

Prediction .....

Explanation .....

.....

.....

.....

.....

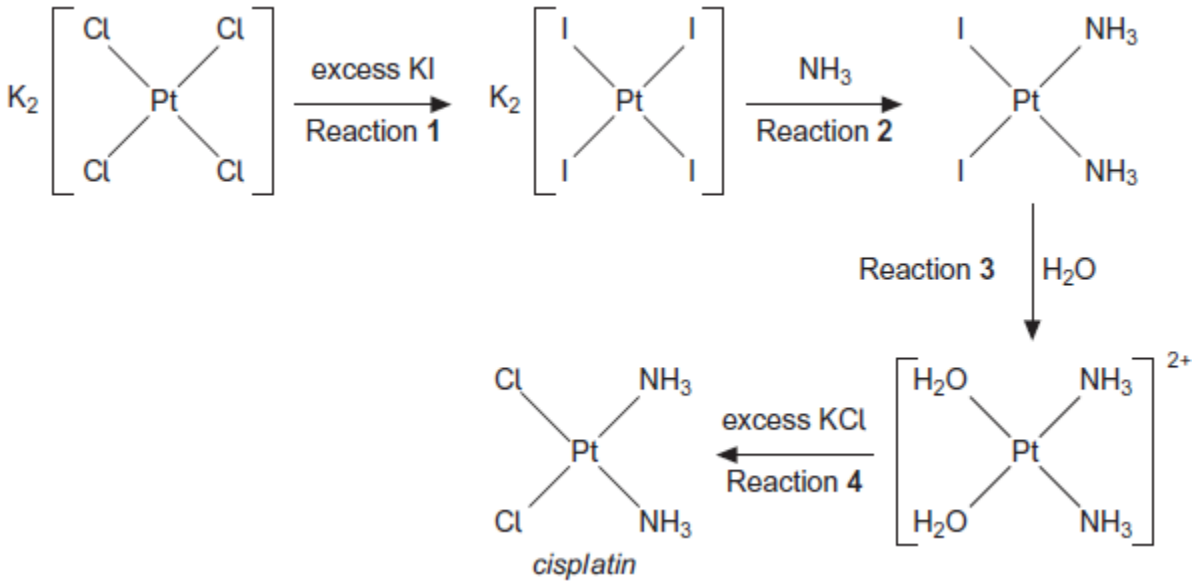
(3)
(Total 15 marks)

25 Complexes containing transition elements have a wide variety of uses including acting as dyestuffs like *Prussian Blue*.

Cisplatin is a platinum-based chemotherapy drug used to treat various types of cancers. It was the first member of a class of anti-cancer drugs that react with DNA in tumour cells.

Cisplatin is prepared from K_2PtCl_4 according to the following scheme.

All the reactions shown are reversible.



(a) Name the type of reaction occurring in all four steps of the scheme.

.....

(1)

(b) Explain why an excess of potassium iodide is used in Reaction **1**.

.....

.....

.....

(2)

(c) (i) Write an equation for Reaction **1**.

.....

.....

(1)

(ii) Calculate the percentage atom economy for the formation of K_2PtI_4 in Reaction **1**. Show your working.

.....

.....

.....

.....

(2)

(d) In Reaction **3**, silver nitrate solution is added to improve the yield of product.

(i) Write the **simplest ionic** equation for the reaction of iodide ions with silver nitrate.

.....

(1)

(ii) Suggest why addition of silver nitrate improves the yield of product from Reaction **3**.

.....

.....

(1)

(e) Suggest two reasons, other than poor practical technique, why the overall yield of *cisplatin* in this synthesis may be low.

Reason 1 .....

.....

Reason 2 .....

.....

(2)

(f) The *cisplatin* formed in Reaction **4** is impure. Outline how the impure solid is purified by recrystallisation.

.....

.....

.....

.....

.....

(3)

(g) Platinum compounds are highly toxic.

(i) State why *cisplatin* is used in cancer treatment despite its toxicity.

.....

.....

(1)

(ii) Suggest a suitable precaution that should be taken by medical staff when using *cisplatin*.

.....

(1)

(Total 15 marks)

26 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

.....

(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.

.....

(1)

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

.....

.....

(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.

.....

.....

.....

.....

.....

(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

.....

Half-equation 2

.....

(2)

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

.....

(1)

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

.....

.....

.....

.....

(2)

(Total 12 marks)

27 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

.....

First propagation step

.....

Second propagation step

.....

A termination step producing butane.

.....

(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.

.....

(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.

.....

(1)

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

.....

.....

.....

(2)

(Total 13 marks)

28 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.

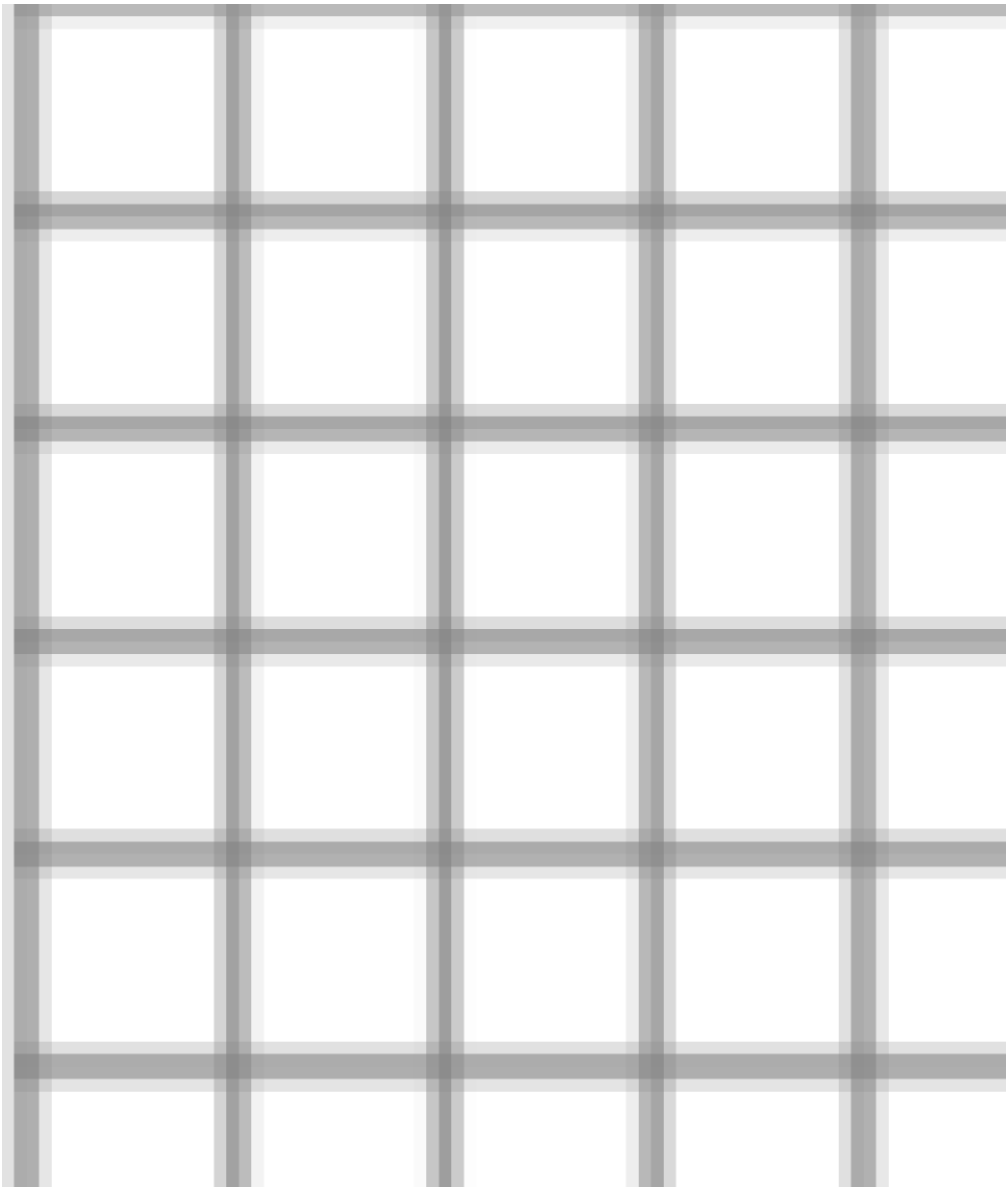
A chemist sampled the effluent at different pressures. For each pressure, a 250 cm^3 sample of effluent was taken in a measuring cylinder and poured into a weighed beaker. The water was evaporated by heating and the beaker reweighed. The following results were obtained.

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.

.....

.....

(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.

.....

.....

.....

(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.

.....

.....

.....

.....

(2)

(e) Consider your graph.

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

.....

.....

.....

(1)

(ii) Identify the anomalous results, if any.

.....

.....

(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).

.....

.....

.....

(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.

.....

.....

(1)

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

.....

.....

(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.

.....

.....

(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.

.....

.....

(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.

.....

(1)

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

.....

.....

(1)

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

.....

.....

.....

(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.

.....

(1)

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

.....

(1)

(Total 22 marks)

29 For each of the following reactions, select from the list below, the **formula** of a sodium halide that would react as described.

NaF NaCl NaBr NaI

Each **formula** may be selected once, more than once or not at all.

(a) This sodium halide is a white solid that reacts with concentrated sulfuric acid to give a brown gas.

Formula of sodium halide .....

(1)

(b) When a solution of this sodium halide is mixed with silver nitrate solution, no precipitate is formed.

Formula of sodium halide .....

(1)

(c) When this solid sodium halide reacts with concentrated sulfuric acid, the reaction mixture remains white and steamy fumes are given off.

Formula of sodium halide .....

(1)

(d) A colourless aqueous solution of this sodium halide reacts with orange bromine water to give a dark brown solution.

Formula of sodium halide .....

(1)

(Total 4 marks)

30 (a) When chlorine gas dissolves in cold water, a pale green solution is formed. In this solution, the following equilibrium is established.

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

Give the formula of the species responsible for the pale green colour in the solution of chlorine in water.

Use Le Chatelier's principle to explain why the green colour disappears when sodium hydroxide solution is added to this solution.

.....

.....

.....

.....

.....

.....

(3)

(b) Consider the following reaction in which iodide ions behave as reducing agents.

$$Cl_2(aq) + 2I^-(aq) \rightarrow I_2(aq) + 2Cl^-(aq)$$

In terms of electrons, state the meaning of the term *reducing agent*.

Deduce the half-equation for the conversion of chlorine into chloride ions.

Explain why iodide ions are stronger reducing agents than chloride ions.

.....

.....

.....

.....

.....

.....

.....

.....

(4)

(c) When chlorine reacts with water in bright sunlight, only two products are formed. One of these products is a colourless, odourless gas and the other is an acidic solution that reacts with silver nitrate solution to give a white precipitate.

Write an equation for the reaction of chlorine with water in bright sunlight.

Name the white precipitate and state what you would observe when an excess of aqueous ammonia is added to it.

.....

.....

.....

.....

.....

.....

.....

.....

(3)

(d) The reaction of chlorine with ethene is similar to that of bromine with ethene.

Name and outline a mechanism for the reaction of chlorine with ethene to form 1,2-dichloroethane, as shown by the following equation.

$$H_2C{=}CH_2 + Cl_2 \rightarrow ClCH_2CH_2Cl$$

(5)
(Total 15 marks)

31 Acidified silver nitrate solution can be used to identify and distinguish between halide ions in solution.

(a) Explain why hydrochloric acid should **not** be used to acidify the silver nitrate.

.....

.....

(1)

(b) State and explain what would be observed when acidified silver nitrate solution is added to a solution of sodium fluoride.

Observation .....

Explanation ….....

(2)

(c) State what would be observed when acidified silver nitrate solution is added to a solution containing iodide ions. Write the **simplest ionic** equation for the reaction that occurs.

Observation .....

Explanation .....

(2)
(Total 5 marks)

32 A chemical company's records refer to the following acids

hydrochloric acid
hydrobromic acid
hydriodic acid
nitric acid
sulfuric acid

A waste tank was thought to contain a mixture of two of these acids. A chemist performed test-tube reactions on separate samples from the waste tank. The results of these tests are shown below.

Test	Reagent	Observations
A	Barium chloride solution	White precipitate
B	Silver nitrate solution	White precipitate

(a) Use the result from Test **A** to identify an acid in the company's records which must be **present** in the waste tank.

.....

(1)

(b) Use the results from Test **A** and Test **B** to identify an acid in the company's records which must be **absent** from the waste tank.

.....

(1)

(c) The chemist suspected that the waste tank contained hydrochloric acid. State how the precipitate formed in Test **B** could be tested to confirm the presence of hydrochloric acid in the waste tank. State what you would observe.

Test .....

.....

Observation .....

.....

(2)

(d) Suggest one reason why carbonate ions could not be present in the waste tank.

.....

(1)
(Total 5 marks)

33 (a) In Peru, chlorine was removed from the water supply due to concerns about it reacting with organic chemicals in the water to produce toxic substances. This resulted in the death of ten thousand people due to cholera. The cholera epidemic ceased when chlorination of the water supply was restarted.

State why chlorine is added to the water supply and give a reason why the amount of chlorine must be carefully monitored. Write an equation for the reaction of chlorine with water.

(3)

(b) How can the addition of an aqueous solution of chlorine be used to distinguish between aqueous solutions of sodium bromide and sodium iodide?

State any observations you would make and write equations for the reactions occurring.

(4)

(c) How can reactions with concentrated sulphuric acid be used to distinguish between solid samples of sodium bromide and sodium iodide?

State the observations you would make and give all the oxidation and reduction products formed in both reactions. Using half-equations, construct an overall equation for **one** of these redox reactions.

(11)
(Total 18 marks)

34 (a) Explain, by referring to electrons, the meaning of the terms *reduction* and *reducing agent*.

(2)

(b) Iodide ions can reduce sulphuric acid to three different products.

(i) Name the **three** reduction products and give the oxidation state of sulphur in each of these products.

(ii) Describe how observations of the reaction between solid potassium iodide and concentrated sulphuric acid can be used to indicate the presence of any **two** of these reduction products.

(iii) Write half-equations to show how two of these products are formed by reduction of sulphuric acid.

(10)

(c) Write an equation for the reaction that occurs when chlorine is added to cold water. State whether or not the water is oxidised and explain your answer.

(3)
(Total 15 marks)

35 Which one of the following is the electron arrangement of the strongest reducing agent?

A $1s^2\ 2s^2\ 2p^5$

B $1s^2\ 2s^2\ 2p^6\ 3s^2$

C $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

D $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$

(Total 1 mark)

36 (a) State the trend in electronegativity of the elements down Group VII. Explain this trend.

Trend .....

Explanation .....

.....

.....

(3)

(b) (i) State the trend in reducing ability of the halide ions down Group VII.

.....

(ii) Give an example of a reagent which could be used to show that the reducing ability of bromide ions is different from that of chloride ions.

.....

(2)

(c) The addition of silver nitrate solution followed by dilute aqueous ammonia can be used as a test to distinguish between chloride and bromide ions. For each ion, state what you would observe if an aqueous solution containing the ion was tested in this way.

Observations with chloride ions .....

.....

Observations with bromide ions .....

.....

(4)

(d) Write an equation for the reaction between chlorine and cold, dilute aqueous sodium hydroxide. Give two uses of the resulting solution.

Equation .....

Use 1 .....

Use 2 .....

(3)
(Total 12 marks)

37 (a) State and explain the trend in electronegativity down Group VII from fluorine to iodine.

Trend .....

Explanation .....

.....

.....

(3)

(b) State what you would observe when chlorine gas is bubbled into an aqueous solution of potassium iodide. Write an equation for the reaction that occurs.

Observation .....

Equation .....

(2)

(c) Identify **two** sulphur-containing reduction products formed when concentrated sulphuric acid oxidises iodide ions. For each reduction product, write a half-equation to illustrate its formation from sulphuric acid.

Reduction product 1 .....

Half-equation .....

Reduction product 2 .....

Half-equation .....

(4)

(d) Write an equation for the reaction between chlorine gas and dilute aqueous sodium hydroxide. Name the **two** chlorine-containing products of this reaction and give the oxidation state of chlorine in each of these products.

Equation .....

Name of product 1 .....

Oxidation state of chlorine in product 1 .....

Name of product 2 .....

Oxidation state of chlorine in product 2 .....

(5)
(Total 14 marks)

38 (a) (i) The addition of aqueous silver nitrate, followed by concentrated aqueous ammonia, can be used to distinguish between separate aqueous solutions of sodium bromide and sodium iodide.
Record what is observed in the table below.

	The addition of $AgNO_3(aq)$	followed by	the addition of concentrated $NH_3(aq)$
Observation with NaBr(aq)			
Observation with NaI(aq)			

(ii) Explain why it is not possible to distinguish between separate solutions of sodium nitrate and sodium fluoride by the addition of silver nitrate solution.

.....

(5)

(b) When aqueous sodium thiosulphate is added to solid silver bromide a reaction occurs and a colourless solution is formed.

(i) Identify the silver-containing species present in the colourless solution.

.....

(ii) Write an equation for this reaction.

.....

(iii) Give **one** use of this reaction.

.....

(3)

(c) Aqueous silver nitrate can be used to distinguish between chloroethanoic acid and ethanoyl chloride.

(i) Draw the structure of ethanoyl chloride. Predict what, if anything, you would observe when ethanoyl chloride is added to aqueous silver nitrate.

Structure of ethanoyl chloride

Observation .....

.....

(ii) Draw the structure of chloroethanoic acid. Predict what, if anything, you would observe when chloroethanoic acid is added to aqueous silver nitrate.

Structure of chloroethanoic acid

Observation .....

.....

(4)

(d) (i) Tollens' reagent is formed by the addition of aqueous ammonia to aqueous silver nitrate. Identify the silver-containing complex present in Tollens' reagent and state its shape.

Silver-containing complex .....

Shape…..

.....

(ii) Draw the structure of methanoic acid. By reference to this structure, suggest why a silver mirror is formed when this acid reacts with Tollens' reagent.

Structure .....

Explanation…….....

.....

(iii) Deduce the identity of a carbon-containing species formed when methanoic acid reacts with Tollens' reagent.

.....

(5)
(Total 17 marks)

39 Which one of the following statements is correct?

A The first ionisation energies of the elements in Period 3 show a general decrease from sodium to chlorine.

B The electronegativities of Group 2 elements decrease from magnesium to barium.

C The strength of the intermolecular forces increases from hydrogen fluoride to hydrogen chloride.

D The ability of a halide ion to act as a reducing agent decreases from fluoride to iodide.

(Total 1 mark)

40 Which one of the following reactions does **not** involve donation of an electron pair?

A $H^+ + CH_3NH_2 \rightarrow CH_3NH_3^+$

B $AlCl_3 + Cl^- \rightarrow A1C1_4^-$

C $CH_3Cl + CN^- \rightarrow CH_3CN + Cl^-$

D $\frac{1}{2}Cl_2 + I^- \rightarrow Cl^- + \frac{1}{2}I_2$

(Total 1 mark)

41 (a) State the trend in the boiling points of the halogens from fluorine to iodine and explain this trend.

Trend .....

Explanation .....

.....

.....

(4)

(b) Each of the following reactions may be used to identify bromide ions. For each reaction, state what you would observe and, where indicated, write an appropriate equation.

(i) The reaction of aqueous bromide ions with chlorine gas

Observation .....

Equation .....

(ii) The reaction of aqueous bromide ions with aqueous silver nitrate followed by the addition of concentrated aqueous ammonia

Observation with aqueous silver nitrate .....

Equation .....

Observation with concentrated aqueous ammonia .....

.....

(iii) The reaction of solid potassium bromide with concentrated sulphuric acid

Observation 1 .....

Observation 2 .....

(7)

(c) Write an equation for the redox reaction that occurs when potassium bromide reacts with concentrated sulphuric acid.

.....

(2)

(Total 13 marks)

42 Chlorine and bromine are both oxidising agents.

(a) Define an *oxidising agent* in terms of electrons.

.....

(1)

(b) In aqueous solution, bromine oxidises sulphur dioxide, SO_2, to sulphate ions, SO_4^{2-}

(i) Deduce the oxidation state of sulphur in SO_2 and in SO_4^{2-}

SO_2 .....

SO_4^{2-} .....

(ii) Deduce a half-equation for the reduction of bromine in aqueous solution.

.....

(iii) Deduce a half-equation for the oxidation of SO_2 in aqueous solution forming SO_4^{2-} and H^+ ions.

.....

(iv) Use these two half-equations to construct an overall equation for the reaction between aqueous bromine and sulphur dioxide.

.....

(5)

(c) Write an equation for the reaction of chlorine with water. Below each of the chlorine-containing products in your equation, write the oxidation state of chlorine in that product.

.....

.....

(3)

(d) Give a reason why chlorine is not formed when solid potassium chloride reacts with concentrated sulphuric acid.

.....

(1)

(e) Write an equation for the reaction between solid potassium chloride and concentrated sulphuric acid.

.....

(1)

(f) Solid potassium bromide undergoes a redox reaction with concentrated sulphuric acid.

(i) Give the oxidation product formed from potassium bromide.

.....

(ii) Give the reduction product formed from sulphuric acid.

.....

(2)

(Total 13 marks)

43 (a) Describe and explain the trend in the boiling points of the elements down Group VII from fluorine to iodine.

(4)

(b) Describe what you would observe when aqueous silver nitrate, followed by dilute aqueous ammonia, is added to separate aqueous solutions of sodium chloride and sodium bromide.

(4)

(c) State the trend in the oxidising abilities of the elements down Group VII from chlorine to iodine.
Explain how this trend can be shown by displacement reactions between halogens and halide ions in aqueous solutions.
Illustrate your answer with appropriate observations and equations.

(7)
(Total 15 marks)

44 (a) State and explain the trend in electronegativity down Group VII from fluorine to iodine.

Trend .....

Explanation ….....

.....

(3)

(b) (i) Describe what you would observe when an aqueous solution of bromine is added to an aqueous solution containing iodide ions. Write an equation for the reaction occurring.

Observation .....

Equation .....

(ii) Explain why bromine does not react with aqueous chloride ions.

.....

.....

(3)

(c) Describe what you would observe when aqueous silver nitrate is added to separate aqueous solutions of potassium fluoride and potassium bromide.

Observation with KF(aq) .....

Observation with KBr(aq) .....

(2)

(d) Write an equation to show how solid potassium fluoride reacts with concentrated sulphuric acid.

.....

(1)

(e) Write an equation for the redox reaction of sodium bromide with concentrated sulphuric acid.

.....

(2)
(Total 11 marks)

45 (a) Concentrated sulphuric acid can be reduced by some solid sodium halides to H_2S

(i) Give the oxidation state of sulphur in H_2S

.....

(ii) Give **one** solid sodium halide which will reduce concentrated sulphuric acid, forming H_2S

.....

(iii) State **one** way in which the presence of H_2S could be recognised.

.....

(iv) Write a half-equation for the formation of H_2S from sulphuric acid.

.....

(4)

(b) A different solid sodium halide reacts with concentrated sulphuric acid without reduction forming a halogen-containing product **X**.

(i) Suggest an identity for **X**.

.....

(ii) Identify the solid sodium halide which produces **X**.

.....

(iii) State the role of sulphuric acid in the formation of **X**.

.....

(iv) Write an equation for the reaction with concentrated sulphuric acid in which **X** is formed.

.....

(4)
(Total 8 marks)

46 (a) When using silver nitrate to test for the presence of chloride ions in an aqueous solution, it is important to add another reagent to prevent interference by any carbonate ions which would form a white precipitate of Ag_2CO_3

(i) Identify this other reagent.

.....

(ii) Write an equation to show how this other reagent reacts with sodium carbonate.

.....

(2)

(b) The presence of some halide ions in solution can be detected using aqueous silver nitrate and aqueous ammonia.

(i) Identify a halide ion which, on addition of aqueous silver nitrate, forms a precipitate that is insoluble in concentrated aqueous ammonia.

.....

(ii) Identify a halide ion which cannot be detected using these reagents.

.....

(2)

(c) A mixture of two precipitates, **P** and **Q**, was formed by adding aqueous silver nitrate to a solution containing two different halide ions. Precipitate **P** dissolved on addition of an excess of dilute aqueous ammonia. The remaining precipitate, **Q**, was filtered off.

(i) Identify the halide ion in **P**.

.....

(ii) Precipitate **Q** was soluble in concentrated aqueous ammonia. Identify the halide ion in **Q**.

.....

(2)
(Total 6 marks)

47 The boiling points of the halogens increase down Group VII because

A covalent bond strengths increase.

B bond polarities increase.

C the surface areas of the molecules increase.

D electronegativities increase.

(Total 1 mark)

48 An aqueous solution of a sodium salt gave no precipitate when treated with either silver nitrate solution or barium chloride solution. Which one of the following could be the formula of the sodium salt?

A NaI

B Na_2SO_4

C NaBr

D NaF

(Total 1 mark)

49 On heating, magnesium reacts vigorously with element **X** to produce compound **Y**. An aqueous solution of **Y**, when treated with aqueous silver nitrate, gives a white precipitate that is readily soluble in dilute aqueous ammonia. What is the minimum mass of **X** that is needed to react completely with 4.05 g of magnesium?

A 11.83 g

B 5.92 g

C 5.33 g

D 2.67 g

(Total 1 mark)

50 Which one of the following can act as an oxidising agent but not as a reducing agent?

A CH_3CHO

B Fe^{2+}

C I^-

D MnO_4^-

(Total 1 mark)

51 (a) Samples of solid sodium fluoride, sodium chloride, sodium bromide and sodium iodide are each warmed separately with concentrated sulphuric acid. All four compounds react with concentrated sulphuric acid but only two can reduce it.

(i) Identify the **two** halides which do **not** reduce concentrated sulphuric acid. Write an equation for the reaction which does occur with **one** of these two halides.

(ii) Identify the **two** halides which reduce concentrated sulphuric acid to sulphur dioxide. Using half-equations for the oxidation and reduction processes, deduce an overall equation for the formation of sulphur dioxide when concentrated sulphuric acid reacts with **one** of these halides.

(iii) In addition to sulphur dioxide, two further reduction products are formed when one of these two halides reacts with concentrated sulphuric acid. Identify the two reduction products and write a half-equation to show the formation of **one** of them from concentrated sulphuric acid.

(9)

(b) How would you distinguish between separate solutions of sodium chloride, sodium bromide and sodium iodide using solutions of silver nitrate and ammonia?

(6)

(Total 15 marks)

52 Which one of the following statements concerning halogen chemistry is true?

A Sodium chloride produces chlorine when treated with concentrated sulphuric acid.

B Sodium chloride produces chlorine when treated with bromine.

C Sodium bromide produces bromine when treated with concentrated sulphuric acid.

D Sodium bromide produces bromine when treated with iodine in aqueous potassium iodide.

(Total 1 mark)

53 An aqueous solution of a white solid gives a yellow precipitate with aqueous silver nitrate. The formula of the white solid could be

A AgBr

B AgI

C NaBr

D NaI

(Total 1 mark)

54 What will you see when a solution of silver nitrate is added to a solution containing bromide ions, and concentrated aqueous ammonia is added to the resulting mixture?

A a white precipitate soluble in concentrated aqueous ammonia

B a white precipitate insoluble in concentrated aqueous ammonia

C a cream precipitate soluble in concentrated aqueous ammonia

D a yellow precipitate insoluble in concentrated aqueous ammonia

(Total 1 mark)

55 Which one of the following statements is true?

A A blue solution containing the ion $[CoCl_4]^{2-}$ turns pink when added to an excess of water.

B A purple solution is formed when chlorine is bubbled into aqueous sodium bromide.

C A yellow precipitate is formed when aqueous silver nitrate is added to aqueous sodium chloride.

D A green solution containing the ion $[CuCl_4]^{2-}$ turns blue when added to an excess of concentrated hydrochloric acid.

(Total 1 mark)

56 In which one of the following reactions does the metal species undergo reduction?

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

B $[Cu(H_2O)_6]^{2+} + 4Cl^- \rightarrow [CuCl_4]^{2-} + 6H_2O$

C $CrO_7^{2-} + 2OH^- \rightarrow 2CrO_4^{2-} + H_2O$

D $TiO_2 + 2C + 2Cl_2 \rightarrow TiCl_4 + 2CO$

(Total 1 mark)

57 A white salt dissolves in water to give a solution which gives a cream coloured precipitate when aqueous silver nitrate is added. This precipitate is insoluble in dilute aqueous ammonia but is soluble in concentrated aqueous ammonia. The original white salt could be

A AgI

B NaI

C AgBr

D NaBr

(Total 1 mark)

58 When vanadium reacts with chlorine at 400°C, a brown compound is obtained. When an aqueous solution containing 0.193 g of this compound was treated with aqueous silver nitrate all the chlorine in the compound was precipitated as silver chloride. The mass of silver chloride (AgCl) produced was 0.574 g. Which one of the following could be the formula of the brown compound?

A VCl

B VCl_2

C VCl_3

D VCl_4

(Total 1 mark)

59 The reaction between sodium iodide and concentrated phosphoric acid produces hydrogen iodide but no iodine. The reaction of sodium iodide with concentrated sulphuric acid produces mainly iodine. The difference in product occurs because, in comparison with sulphuric acid, phosphoric acid is

A the weaker acid.

B the stronger oxidising agent.

C the weaker oxidising agent.

D the stronger reducing agent.

(Total 1 mark)

60 Which one of the following is **not** a correct trend down Group VII?

A The first ionisation energy of the atom decreases.

B The oxidising power of the element increases.

C The electronegativity of the atom decreases.

D The boiling point of the element increases.

(Total 1 mark)

Mark schemes

1

(a) (i) $\mathbf{2}Cl^- \longrightarrow Cl_2 + \mathbf{2}e^-$

Ignore state symbols

Credit loss of electrons from LHS

Credit multiples

Do not penalise absence of charge on electron

1

(ii) +7 ***OR*** 7 ***OR*** VII ***OR*** +VII

Allow Mn^{+7} and 7+

1

(iii) $MnO_4^- + 8H^+ + 5\mathbf{e}^- \longrightarrow Mn^{2+} + 4H_2O$

Ignore state symbols

Credit loss of electrons from RHS

Credit multiples

Do not penalise absence of charge on electron

1

(b) (i) $Cl_2 + \mathbf{2}Br^- \longrightarrow \mathbf{2}Cl^- + Br_2$

OR

$\frac{1}{2}Cl_2 + Br^- \longrightarrow Cl^- + \frac{1}{2}Br_2$

One of these two equations <u>only</u>

Ignore state symbols

1

(ii) (Turns to) <u>yellow / orange / brown</u> (solution)

Penalise "red / reddish" as the only colour

Accept "red-brown" and "red-orange"

Ignore "liquid"

Penalise reference to a product that is a gas or a precipitate

1

(iii) (Chlorine) <u>gains electron(s)</u> / <u>takes electron(s)</u> / <u>accepts electron(s)</u> (from the bromide ions)

OR

(Chlorine) <u>causes another species</u> (Br^-) <u>to lose electron</u>(s)

Penalise "electron pair acceptor"

Not simply "causes loss of electrons"

1

(c) **M1** $2Cl_2 + 2H_2O \longrightarrow 4HCl + O_2$

($4H^+ + 4Cl^-$)

M2 Oxidation state **−1**

Ignore state symbols

Credit multiples

***M2** consequential on HCl or Cl^- which **must** be the only chlorine-containing product in the (un)balanced equation.*

*For **M2** allow Cl^{-1} or Cl^{1-} but **not** Cl^-*

2

(d) **M1 The relative size (of the molecules / atoms)**

Chlorine is <u>smaller</u> than bromine ***OR*** has fewer electrons / electron shells

*For **M1** ignore whether it refers to molecules or atoms.*

OR It is smaller / It has a smaller atomic radius / it is a smaller molecule / atom (or converse)

***CE=0** for the clip for reference to (halide) ions or incorrect statements about relative size*

Ignore molecular mass and M_r

M2 How size of the <u>intermolecular force</u> affects energy needed

Ignore shielding

The <u>forces between</u> chlorine / Cl_2 <u>molecules</u> are weak<u>er</u> (than the forces between bromine / Br_2 <u>molecules</u>)
(or converse for bromine)
OR chlorine / Cl_2 has <u>weaker / fewer / less</u> (VdW) <u>intermolecular forces / forces between molecules</u>
(or converse for bromine)

***QoL in M2** for clear reference to the difference in size <u>of the force between molecules</u>. Reference to Van der Waals forces alone is not enough.*

*Penalise **M2** if (covalent) bonds are broken*

2

[10]

2 (a) **M1** acidified potassium dichromate or $K_2Cr_2O_7$ / H_2SO_4

OR $K_2Cr_2O_7$ / H^+ ***OR*** acidified $K_2Cr_2O_7$

M2 (orange to) green solution ***OR*** goes green

M3 (solution) remains orange or no reaction or no (observed) change

*If no reagent or incorrect reagent in **M1**, **CE = 0** and no marks for **M1**, **M2** or **M3***

*If incomplete / inaccurate attempt at reagent e.g. "dichromate" or "dichromate(IV)" or incorrect formula or no acid, **penalise M1 only and mark on***

*For **M2** ignore dichromate described as "yellow" or "red"*

*For **M3** ignore "nothing (happens)" or "no observation"*

Alternative using $KMnO_4$ / H_2SO_4

M1 acidified potassium manganate(VII) / potassium permanganate or $KMnO_4$ / H_2SO_4

OR $KMnO_4$ / H^+ ***OR*** acidified $KMnO_4$

M2 colourless solution ***OR*** goes colourless

M3 (solution) remains purple or no reaction or no (observed) change

*For **M1***

*If incomplete / inaccurate attempt at reagent e.g. "manganate" or "manganate(IV)" or incorrect formula or no acid, **penalise M1 only and mark on***

*Credit alkaline $KMnO_4$ for possible full marks but **M2** gives brown precipitate or solution goes green*

3

(b) **M1** (Shake with) Br_2 ***OR*** bromine (water) ***OR*** bromine (in CCl_4 / organic solvent)

M2 (stays) orange / red / yellow / brown / the same

OR no reaction ***OR*** no (observed) change

M3 decolourised / goes colourless / loses its colour / orange to colourless

*If no reagent or incorrect reagent in **M1**, **CE = 0** and no marks for **M1**, **M2** or **M3***

*If incomplete / inaccurate attempt at reagent (e.g. Br), **penalise M1 only and mark on***

*No credit for combustion observations; **CE = 0***

*For **M2 in every case***

Ignore "nothing (happens)"

Ignore "no observation"

Ignore "clear"

***OR* as alternatives**

Use $KMnO_4$ / H_2SO_4

M1 acidified potassium manganate(VII) / potassium permanganate ***OR*** $KMnO_4$ / H_2SO_4

OR $KMnO_4$ / H^+ ***OR*** acidified $KMnO_4$

M2 (stays) <u>purple</u> or no reaction or no (observed) change

M3 decolourised / goes colourless / loses its colour

Use iodine

M1 iodine or I_2 / KI or iodine solution

M2 no change

M3 decolourised / goes colourless / loses its colour

Use concentrated sulfuric acid

M1 <u>concentrated</u> H_2SO_4

M2 no change

M3 brown

***For M1**, it must be a whole reagent and / or correct formula*

For M1** penalise incorrect attempt at correct formula, but mark **M2** and **M3

With potassium manganate(VII)

*If incomplete / inaccurate attempt at reagent e.g. "manganate" or "manganate(IV)" or incorrect formula or no acid, **penalise M1 only and mark on***

*Credit alkaline / neutral $KMnO_4$ for possible full marks but **M3** gives <u>brown precipitate</u> or solution goes <u>green</u>*

Apply similar guidance for errors in the formula of iodine or concentrated sulfuric acid reagent as those used for other reagents.

3

(c) **M1** Any soluble chloride including hydrochloric acid (ignore concentration)

M2 white precipitate or white solid / white suspension

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

***OR* as an alternative**

M1 Any soluble iodide including HI

M2 yellow precipitate or yellow solid / yellow suspension

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

***OR* as an alternative**

M1 Any soluble bromide including HBr

M2 cream precipitate or cream solid / cream suspension

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

***OR* as an alternative**

M1 NaOH or KOH or any soluble carbonate

M2 brown precipitate or brown solid / brown suspension with NaOH / KOH (white precipitate / solid / suspension with carbonate)

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

*If no reagent or incorrect reagent or insoluble chloride in **M1**, **CE = 0** and no marks for **M1**, **M2** or **M3***

Allow chlorine water

*If incomplete reagent (e.g. chloride ions) or inaccurate attempt at formula of chosen chloride, or chlorine, **penalise M1 only and mark on***

*For **M2** require the word "white" and some reference to a solid. Ignore "cloudy solution" OR "suspension" (similarly for the alternatives)*

*For **M3***

Ignore "nothing (happens)"

Ignore "no observation"

Ignore "clear" on its own

Ignore "dissolves"

3

(d) **M1** Any <u>soluble</u> <u>sulfate</u> including (dilute or aqueous) sulfuric acid

M2 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

M3 <u>white precipitate</u> or <u>white solid / white suspension</u>

*If no reagent or incorrect reagent or insoluble sulfate in **M1**, **CE = 0** and no marks for **M1**, **M2** or **M3***

Accept $MgSO_4$ and $CaSO_4$ but not barium, lead or silver sulfates

*If concentrated sulfuric acid or incomplete reagent (e.g. sulfate ions) or inaccurate attempt at formula of chosen sulfate, **penalise M1 only and mark on***

*For **M3 (or M2 in the alternative)** require the word "white" and some reference to a solid.*

Ignore "cloudy solution" OR "suspension"

*For **M2 (or M3 in the alternative)***

Ignore "nothing (happens)"

Ignore "no observation"

Ignore "clear" <u>on its own</u>

Ignore "dissolves"

***OR* as an alternative**

M1 NaOH or KOH

M2 <u>white precipitate</u> or <u>white solid / white suspension</u>

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

*If incomplete reagent (e.g. hydroxide ions) or inaccurate attempt at formula of chosen hydroxide, **penalise M1 only and mark on***

*If **M1** uses NH_3 (dilute or concentrated) **penalise M1 only and mark on***

3

[12]

3 (a) $Cl_2 + H_2O \rightleftharpoons HOCl + HCl$

Allow the products shown as ions.

1

Cl_2 = 0, HOCl = +1 and HCl = −1

1 mark for all three oxidation states correct. Allow a reaction arrow in this equation.

Oxidation states must match the species

1

(b) Hydroxide / alkali ions react with the acids

Mark independently

1

Equilibrium moves to the right

1

(c) Only used in small amounts

1

The health benefits outweigh the risks

1

[6]

4 (a) $2NaBr + 2H_2SO_4 \longrightarrow Na_2SO_4 + Br_2 + SO_2 + 2H_2O$

Allow ionic equation

$2Br^- + 2H_2SO_4 \longrightarrow Br_2 + SO_4^{2-} + SO_2 + 2H_2O$

1

Br^- ions are bigger than Cl^- ions

1

Therefore Br^- ions more easily oxidised / lose an electron more easily (than Cl^- ions)

1

(b) This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.

Level 3

All stages are covered and the explanation of each stage is generally correct and virtually complete. Stages 1 and 2 are supported by correct equations.

Answer communicates the whole process coherently and shows a logical progression from stage 1 to stage 2 and then stage 3. The steps in stage 3 are in a logical order.

5–6 marks

Level 2

All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete.

Answer is mainly coherent and shows a progression through the stages. Some steps in each stage may be out of order and incomplete.

3–4 marks

Level 1

Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies, OR only one stage is covered but the explanation is generally correct and virtually complete.

Answer includes some isolated statements, but these are not presented in a logical order or show confused reasoning.

1–2 marks

Level 0

Insufficient correct chemistry to warrant a mark.

0 marks

Indicative chemistry content

***Stage 1**: formation of precipitates*

- *Add silver nitrate*
- *to form precipitates of AgCl and AgBr*
- $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$
- $AgNO_3 + NaBr \rightarrow AgBr + NaNO_3$

***Stage 2**: selective dissolving of AgCl*

- *Add excess of dilute ammonia to the mixture of precipitates*
- *the silver chloride precipitate dissolves*
- $AgCl + 2NH_3 \rightarrow Ag(NH_3)_2^+ + Cl^-$

***Stage 3**: separation and purification of AgBr*

- *Filter off the remaining silver bromide precipitate*
- *Wash to remove soluble compounds*
- *Dry to remove water*

6

(c) $Cl_2 + 2HO^- \longrightarrow OCl^- + Cl^- + H_2O$

1

OCl^- is +1

Cl^- is –1

Both required for the mark

1

[11]

5 D

[1]

6 D

[1]

7 (a) **Q** is calcium or magnesium

1

bromide

1

R is aluminium

1

chloride

1

S is iron(III)

1

sulfate

1

Mark this question independently

(b) $Ba^{2+} + SO_4^{2-} \longrightarrow BaSO_4$

1

$[Fe(H_2O)_6]^{3+} + 3OH^- \longrightarrow Fe(H_2O)_3(OH)_3 + 3H_2O$

1

$2[Fe(H_2O)_6]^{3+} + 3CO_3^{2-} \longrightarrow 2Fe(H_2O)_3(OH)_3 + 3H_2O + 3CO_2$

1

$[Fe(H_2O)_6]^{3+} + 4Cl^- \longrightarrow [FeCl_4]^- + 6H_2O$

1

[10]

8

(a) (i) **M1** (+) 4 **OR** IV

M2 (+) 6 **OR** VI

2

(ii) It / Chlorine has gained / accepted electron(s)

OR

Correctly balanced half-equation eg $Cl_2 + \mathbf{2}e^- \longrightarrow \mathbf{2}Cl^-$

Credit 1 or 2 electrons but not lone pair.

The idea of 'reduction' alone is not enough.

1

(b) (i) $\mathbf{6}KI + \mathbf{7}H_2SO_4 \longrightarrow \mathbf{6}KHSO_4 + \mathbf{3}I_2 + S + \mathbf{4}H_2O$

1

(ii) $\mathbf{2}I^- \longrightarrow I_2 + \mathbf{2}e^-$

OR

$8I^- \longrightarrow 4\mathbf{I}_2 + 8e^-$

Ignore charge on the electron unless incorrect.

Or multiples.

Credit the electrons being subtracted on the LHS.

Ignore state symbols.

1

(iii) $H_2SO_4 + \mathbf{8}H^+ + \mathbf{8}e^- \longrightarrow H_2S + \mathbf{4}H_2O$

OR

$SO_4^{2-} + \mathbf{10}H^+ + \mathbf{8}e^- \longrightarrow H_2S + \mathbf{4}H_2O$

Ignore charge on the electron unless incorrect.
Or multiples.
Credit the electrons being subtracted on the RHS.
Ignore state symbols.

1

(c) (i) $Ag^+ + I^- \longrightarrow AgI$ ONLY

Ignore state symbols.
Not multiples.

1

(ii) The precipitate / solid / it does not dissolve / is insoluble / remains

OR a white / cream / yellow solid / precipitate

OR stays the same

OR no (visible / observable) change

OR no effect / no reaction

Ignore 'nothing (happens)'.
Ignore 'no observation'.

1

(iii) The silver nitrate is acidified to

- react with / remove (an)ions that would interfere with the test
  Credit a correct reference to ions that give a 'false positive'.
- prevent the formation of other silver precipitates / insoluble silver compounds that would interfere with the test
  Do not penalise an incorrect formula for an ion that is written in addition to the name.
- remove (other) ions that react with the silver nitrate
  If only the formula of the ion is given, it must be correct.
- react with / remove carbonate / hydroxide / sulfite (ions)
  Ignore 'sulfate'.

1

(iv) HCl would form a (white) precipitate / (white) solid (with silver nitrate and this would interfere with the test)

*It is not sufficient simply to state either that it will interfere **or** simply that the ions / compounds react to form AgCl*

1

(d) (i) Any **one** from

Ignore 'to clean water'.

- to sterilise / disinfect water
  Ignore 'water purification' and 'germs'.
- to destroy / kill microorganisms / bacteria / microbes / pathogens
  Credit 'remove bacteria etc' / prevent algae.

1

(ii) The (health) benefit outweighs the risk

OR

a clear statement that once it has done its job, little of it remains

OR

used in (very) dilute concentrations / small amounts / low doses

1

(iii) $Cl_2 + H_2O \longrightarrow HClO + HCl$

OR

$Cl_2 + H_2O \longrightarrow \mathbf{2}H^+ + ClO^- + Cl^-$

OR

$\mathbf{2}Cl_2 + \mathbf{2}H_2O \longrightarrow \mathbf{4}HCl + O_2$

Credit HOCl or ClOH
Or multiples.
Credit other ionic or mixed representations.
Ignore state symbols.

1

(e) **In either order - Both required for one mark only**

Credit correct ionic formulae.

NaClO (OR NaOCl) **and** NaCl

Give credit for answers in equations unless contradicted.

1

[14]

9

(a) (i) $SrCl_2(aq) + Na_2SO_4(aq) \rightarrow SrSO_4(s) + 2NaCl(aq)$

Allow multiples, including fractions.
Allow ionic equations.
Lose this mark if any of the state symbols are missing or incorrect.

1

(ii) Add nitric acid to the mixture (until in excess)

Do not allow any suggestion that the solution is an emetic.

1

Filter (to isolate strontium sulfate)

1

(b) Insoluble barium sulfate is formed

Allow 'removes barium ions as a precipitate' .

1

(c) Add silver nitrate, then dilute ammonia (solution) **M1**

Do not allow answers which imply silver nitrate and ammonia are added at the same time.

Allow 'add silver nitrate, then concentrated ammonia (solution)'.

*Can score **M1** in the answer for **M3***

1

Cream precipitate **M2**

Allow 'off white precipitate'.

1

No visible change or precipitate dissolves slightly in dilute ammonia **M3**

Allow 'soluble / colourless solution / precipitate dissolves in concentrated ammonia'.

Allow 3 marks for:

*Add dilute ammonia (solution), then silver nitrate **M1***

*No visible change **M2***

*Cream / off white precipitate with silver nitrate **M3***

1

[7]

10 (a) (i) 1.08×10^{-2}

Do not penalise precision but must be to at least 2 significant figures.

Do not accept 1×10^{-2}

1

(ii) $5.4(0) \times 10^{-3}$

Allow (i) / 2

Do not penalise precision but must be to at least 2 significant figures.

1

(iii) 266.6

Lose this mark if answer not given to 1 decimal place.

1

(iv) mass = $5.4(0) \times 10^{-3} \times 266.6 = 1.44$ g **M1**

Allow (ii) × (iii).

1

percentage = 1.44 × 100 / 2.25 = 64.0 **M2**

*Allow consequential answer from **M1***

Lose this mark if answer not given to 3 significant figures.

*Correct answer with no working scores **M2** only.*

1

(v) 1 Would give an incorrect / too large mass (of silver chloride)

Do not allow 'to get an accurate result' without qualification.

1

2 To remove soluble impurities / excess silver nitrate (solution) / strontium nitrate (solution)

Do not allow 'to remove impurities'.

Do not allow 'to remove excess strontium chloride solution'.

1

(b) (i) $Mg^{2+}(aq) + 2OH^{-}(aq) \rightarrow Mg(OH)_2(s)$

Allow $Mg^{2+}(aq) + 2OH^{-}(aq) \rightarrow Mg^{2+}(OH^{-})_2(s)$

Allow multiples, including fractions.

Lose mark if state symbols are missing or incorrect.

Lose mark if incorrect charge on an ion.

1

(ii) Does not produce CO_2 / gas which distends stomach / does not produce wind / does not increase pressure in stomach

Allow 'prevents flatulence' and 'prevents burping'.

Do not allow 'gas' without qualification.

1

(c) $(CH_3COO)_2Ca \rightarrow CH_3COCH_3 + CaCO_3$

Allow multiples.

Allow propanone as C_3H_6O

Allow $(CH_3COO^{-})_2Ca^{2+} \rightarrow CH_3COCH_3 + Ca^{2+}CO_3^{2-}$

1

(d) Ca (salt) - no visible change with sodium chromate(VI) **M1**

Allow 'yellow solution formed' or 'no ppt. forms'.

*Allow **M1** and **M2** in any order.*

1

Sr and Ba (salts) give (yellow) precipitate with sodium chromate(VI) **M2**

Lose this mark if precipitate has an incorrect colour.

1

Sr precipitate (chromate(VI)) dissolves in ethanoic acid / Ba precipitate (chromate(VI)) does not dissolve in ethanoic acid **M3**

*If ethanoic acid is added first, allow access to **M1** and **M3**.*

1

(e) C 42.09 / 12, H 2.92 / 1, N 8.18 / 14, O 37.42 / 16 and S 9.39 / 32.1

Accept any other correct method of working.

If relative atomic mass has been divided by the percentage composition is used then CE = 0 / 2

1

$C_{12}H_{10}N_2O_8S$

Correct answer with no working scores 1 mark only.

1

[15]

11 (a) M1 <u>concentrated sulfuric acid OR c(onc) H_2SO_4</u>

*If no reagent or incorrect reagent in **M1, CE= 0** and no marks for **M2** or **M3***

M2 (cream solid) turns orange
OR <u>orange / red / brown fumes / gas / vapour</u>

*If <u>dilute</u> sulfuric acid **OR** "aq" <u>(alone)</u> **CE=0***

M3 (yellow solid) turns black
OR <u>purple fumes / gas / vapour</u>
OR correct reference to H_2S <u>observation (eg bad egg smell)</u>

*If H_2SO_4 / sulfuric acid given but not stated whether dilute or concentrated, penalise **M1** and mark on for **M2** and **M3***
*If incorrect formula for the acid, penalise **M1** but mark **M2** and **M3***

***OR* as an alternative**

M1 <u>concentrated ammonia</u> ***OR*** <u>c(onc) NH_3</u>

*If NH_3 / ammonia / aq ammonia given, but not stated as <u>concentrated</u> **OR** if <u>dilute</u> ammonia given, penalise **M1** but mark on for **M2** and **M3***
*Ignore "partially" and ignore "clear" in **M2***

M2 (cream solid) dissolves / solution formed

M3 precipitate remains / does not dissolve / insoluble
OR no reaction / no change / (yellow solid) turns to white solid

*If incorrect formula for ammonia, penalise **M1** but mark **M2** and **M3***
*In **M3** for ammonia.*
ignore "nothing (happens)".
ignore "no observation".

3

(b) M1 $AgNO_3$ ***OR*** silver nitrate ***OR*** any soluble silver salt

*If no reagent **OR** incorrect reagent in **M1**, **CE= 0** and no marks for **M2 OR M3***

M2 white precipitate or white solid / white suspension

*An insoluble silver salt OR Tollens' **OR** Ag **OR** ammoniacal silver nitrate or HCl / $AgNO_3$ **CE= 0** for the clip.*

M3 remains colourless ***OR*** no reaction ***OR*** no (observed) change ***OR*** no precipitate

*For **M1***
*Credit acidified (**OR** HNO_3) silver nitrate for **M1** and mark on.*
*If silver ions or incorrect formula for silver nitrate, penalise **M1** but mark **M2** and **M3***

Credit alternative test for nitrate ions

*For **M2***
*Ignore "cloudy solution" **OR** "suspension".*

*For **M3***
Ignore "nothing (happens)".
Ignore "no observation".
Ignore "clear".
Ignore "dissolves".

3

(c) M1 Br_2 ***OR*** bromine (water) ***OR*** bromine (in CCl_4 / organic solvent)

*If no reagent or incorrect reagent in **M1**, **CE= 0** and no marks for **M2** or **M3***

Either Order

M2 (stays) Orange / red / yellow / brown / the same
OR no reaction ***OR*** no (observed) change
OR reference to colour going to cyclohexane layer

*No credit for combustion observations; **CE=0***
*For **M2 in every case**.*
Ignore "nothing (happens)".
Ignore "no observation".
Ignore "clear".

M3 decolourised / goes colourless / loses its colour

With bromine (water)
***For M1**, it must be a whole reagent and / or correct formula.*
If oxidation state given in name, it must be correct.
For M1** penalise incorrect formula, but mark **M2** and **M3

***OR* as an alternative**

Use $KMnO_4/H_2SO_4$

M1 acidified potassium manganate(VII) or $KMnO_4/H_2SO_4$

OR $KMnO_4/ H^+$ ***OR*** acidified $KMnO_4$

M2 (stays) <u>purple</u> or no reaction or no (observed) change

With potassium manganate(VII)
For M1

M3 <u>purple to colourless</u> solution ***OR*** goes <u>colourless</u>

*If "manganate" or "manganate(IV)" or incorrect formula or no acid, penalise **M1** but mark **M2** and **M3***

Credit alternative test using **iodine** (for **M1**)
M2 (brown) to purple or accept no change, M3 colourless
Credit alternative test using <u>concentrated</u> $H_2 SO_4$
M2 no change, M3 brown

*Credit alkaline / neutral $KMnO_4$ for possible full marks but **M3** gives <u>brown precipitate</u> or solution goes <u>green</u>.*

3

(d) M1 Tollens' (reagent) OR ammoniacal silver nitrate OR a description of making Tollens'

(Ignore either $AgNO_3$ or $[Ag(NH_3)_2^+]$ or "the silver mirror test" on their own, but mark M2 and M3)

M2 silver mirror

OR black solid / precipitate (Ignore silver precipitate)

M3 (stays) colourless or no reaction or no (observed) change

*If no reagent or incorrect reagent in **M1**, **CE= 0** and no marks for **M2** or **M3***

For M3 in every case

Ignore "nothing (happens)".

Ignore "no observation".

Alternative using Fehling's (solution)

M1 Fehling's (solution) or Benedict's solution

(Ignore $Cu^{2+}(aq)$ or $CuSO_4$ on their own, but mark M2 and M3)

M2 Red solid / precipitate (Credit Orange or brown solid)

M3 (stays) blue or no reaction or no (observed) change

With potassium dichromate(VI)

For M1

*If "dichromate" or "(potassium) dichromate(IV)" or incorrect formula or no acid, penalise **M1** but mark **M2** and **M3***

Alternative using $K_2Cr_2O_7/H_2SO_4$

M1 acidified potassium dichromate or $K_2Cr_2O_7/H_2SO_4$

OR $K_2Cr_2O_7/H^+$ ***OR*** acidified $K_2Cr_2O_7$

M2 (Orange to) green solution OR goes green

M3 (stays) Orange or no reaction or no (observed) change

*For **M3***

Ignore dichromate described as "yellow" or "red".

With potassium manganate(VII)

For M1

If "manganate" or "(potassium manganate(IV)" or incorrect formula or no acid, penalise M1 but mark M2 and M3

Alternative using $KMnO_4/H_2SO_4$

M1 acidified potassium manganate(VII) or $KMnO_4/H_2SO_4$

OR $KMnO_4/H^+$ ***OR*** acidified $KMnO_4$

M2 purple to colourless solution OR goes colourless

M3 (stays) purple or no reaction or no (observed) change

*Credit alkaline / neutral $KMnO_4$ for possible full marks but **M2** gives brown precipitate or solution goes green.*

3

[12]

12 (a) (i) $\frac{1}{2}Cl_2 + I^- \longrightarrow \frac{1}{2} I_2 + Cl^-$

Only *these two equations.*

OR

$Cl_2 + \mathbf{2}I^- \longrightarrow I_2 + \mathbf{2}Cl^-$

1

(ii) (Solution turns from colourless to) brown / red-brown solution

Allow grey / black solid.

Ignore "purple".

1

(b) $\mathbf{2}Cl_2 + \mathbf{2}H_2O \longrightarrow \mathbf{4}HCl + O_2$

$(\mathbf{4}H^+ + \mathbf{4}Cl^-)$

Credit multiples.

1

(c) M1 **The relative size (of the molecules / atoms)**

Chlorine is smaller than bromine OR has fewer electrons / electron shells

OR It is smaller / It has a smaller atomic radius / it is a smaller molecule / or has smaller M_r

(or converse for bromine)

Ignore general Group 7 statements.

*For **M1** ignore whether it refers to molecules or atoms.*

M2 **How size of the intermolecular force affects energy needed**

The forces between chlorine / Cl_2 molecules are weaker (than the forces between bromine / Br_2 molecules leading to less energy needed to separate the molecules)

(or converse for bromine)

OR chlorine / Cl_2 has weaker / less / fewer forces between molecules ***OR*** chlorine / Cl_2 has weaker / less / fewer intermolecular forces

(or converse for bromine)

CE=0 *for reference to (halide) ions.*

QoL for clear reference to the difference in size of the force between molecules.

*Penalise **M2** if (covalent) bonds are broken.*

2

[5]

13

Test silver nitrate (solution) **(M1)**

Allow an alternative soluble silver salt eg fluoride, sulfate.

Do not allow 'silver ions' but can access second mark.

Incorrect formula loses this mark but can access second mark.

Do not allow 'silver' or an insoluble silver salt and ***cannot*** *access second mark.*

Ignore references to acidification of the silver nitrate.

If an acid is specified it should be nitric acid, but allow sulfuric acid in this case as there are no metal ions present.

If hydrochloric acid is used, CE = 0 / 2.

Do not allow 'add water'.

1

Observation white precipitate **(M2)**

Ignore 'cloudy'.

Do not allow 'white fumes' or 'effervescence'.

Do not allow this mark if test reagent is incorrect or missing.

Allow named indicator paper or named indicator solution for ***M1****.*

Allow correct colour change for ***M2****.*

1

[2]

14 **M1 and M2 (either order)**

Any two from

- purple <u>vapour / gas</u>
- (white solid goes to) black or black / grey or black / purple <u>solid</u>
- bad <u>egg smell</u> or words to this effect

Ignore misty white fumes
Ignore yellow solid
Ignore purple solid
Ignore "goes (dark) brown"

M3

*Or multiples for possible equation in **M3***

The <u>iodide ion(s) / they lose (an) electron(s)</u>

OR

$2I^- \longrightarrow I_2 + 2e^-$

M4

Accept "changes by − 8"

Oxidation state of S changes from **<u>+6 to −2</u>** or **<u>changes by 8</u>**

M5

$H_2SO_4 + \mathbf{8}H^+ + \mathbf{8}e^- \longrightarrow H_2S + \mathbf{4}H_2O$

OR

$SO_4^{2-} + \mathbf{10}H^+ + \mathbf{8}e^- \longrightarrow H_2S + \mathbf{4}H_2O$

[5]

15 (a) M1 $Cl_2 + \mathbf{2}Br^- \longrightarrow \mathbf{2}Cl^- + Br_2$

Accept a correct equation using ½ Cl_2 but no other multiples

M2 solution goes <u>orange / yellow</u> (from colourless)

Ignore reference to brown colour

Penalise incorrect observations eg fumes, precipitates

2

(b) M1 $Cl_2 + 2NaOH \longrightarrow NaClO + NaCl + H_2O$

(NaOCl)

Or a correct ionic equation

Ignore reference to "swimming pools" and to "disinfectant"

M2 bleach or kills bacteria / bacteriacide / micro-organisms / microbes

M3 sodium chlorate(I) ONLY

3

(c) M $Cl_2 + H_2O \rightleftharpoons HClO + HCl$

(HOCl)

*Equilibrium symbol **required** in **M1***

Accept ionic RHS

M2

The (health) benefit outweighs the risk or wtte

OR

a clear statement that once it has done its job, little of it remains

OR

used in (very) dilute concentrations / small amounts / low doses

2

(d) M1 Silver nitrate OR $AgNO_3$ (with or without nitric acid)

*For **M1***

If only the formula is written then it must be correct

If both the formula and the name are written then ignore incorrect attempt at the formula, but penalise an incorrect name

M2 (depends on M1)

white precipitate / white solid

*If the reagent is incomplete eg Ag^+ ions, penalise **M1** and mark on*

M3 $Ag^+ + Cl^- \longrightarrow AgCl$

*Penalise both **M1** and **M2** for alkaline $AgNO_3$ **OR** for the use of HCl to acidify the silver nitrate **OR** for Tollens' reagent*

3

[10]

16 (a) (i) **M1** iodine ***OR*** I_2 OR I_3^-

Ignore state symbols

*Credit **M1** for "iodine solution"*

M2 $Cl_2 + \mathbf{2}I^- \longrightarrow \mathbf{2}Cl^- + I_2$

OR

$\frac{1}{2} Cl_2 + I^- \longrightarrow Cl^- + \frac{1}{2} I_2$

Penalise multiples in M2 except those shown

***M2** accept correct use of I_3^-*

M3 redox or reduction-oxidation or displacement

3

(ii) **M1** (the white precipitate is) <u>silver chloride</u>

***M1** <u>must be named</u> and for <u>this mark</u> ignore incorrect formula*

M2 $Ag^+ + Cl^- \longrightarrow AgCl$

*For **M2** ignore state symbols*

Penalise multiples

M3 (white) precipitate / <u>it dissolves</u>

OR <u>colourless solution</u>

Ignore references to "clear" alone

3

(b) (i) **M1** $H_2SO_4 + \mathbf{2}Cl^- \longrightarrow \mathbf{2}HCl + SO_4^{2-}$

*For **M1** ignore state symbols*

OR $H_2SO_4 + Cl^- \longrightarrow HCl + HSO_4^-$

Penalise multiples for equations and apply the list principle

OR $H^+ + Cl^- \longrightarrow HCl$

M2 hydrogen chloride ***OR*** HCl ***OR*** hydrochloric acid

2

(ii) **M1 and M2 in either order**

*For **M1** and **M2**, ignore state symbols and credit multiples*

M1 $\mathbf{2}I^- \longrightarrow \mathbf{I_2} + \mathbf{2}e^-$

OR

$\mathbf{8}I^- \longrightarrow \mathbf{4}I_2 + \mathbf{8}e -$

Do not penalise absence of charge on the electron

Credit electrons shown correctly on the other side of each equation

M2 $H_2SO_4 + \mathbf{8}H^+ + \mathbf{8}e^- \longrightarrow H_2S + \mathbf{4}H_2O$

OR

$SO_4^{2-} + \mathbf{10}H+ + \mathbf{8}e^- \longrightarrow H_2S + \mathbf{4}H_2O$

Additional equations should not contradict

M3 <u>oxidising agent</u> / <u>oxidises the iodide</u> (ions)

OR

<u>electron acceptor</u>

M4 sulfur ***OR*** S ***OR*** S_2 ***OR*** S_8 ***OR*** sulphur

4

(iii) **M1** The NaOH / OH^- / (sodium) hydroxide reacts with / neutralises the H^+ / acid / HBr (lowering its concentration)

OR a correct neutralisation equation for H^+ or HBr with NaOH or with hydroxide ion

Ignore reference to NaOH reacting with bromide ions

Ignore reference to NaOH reacting with HBrO alone

M2 **Requires a correct statement for M1**

The (position of) equilibrium moves / shifts(from L to R)

- to replace the H^+ / acid / HBr that has been removed / lost
- ***OR*** to increase the H^+ / acid / HBr concentration
- ***OR*** to make more H^+ / acid / HBr / product(s)
- ***OR*** to oppose the loss of H^+ / loss of product(s)
- ***OR*** to oppose the decrease in concentration of product(s)

*In **M2**, answers must refer to the (position of) equilibrium shifts / moves and is not enough to state simply that it / the system / the reaction shifts to oppose the change.*

M3 The (health) benefit outweighs the risk or wtte

OR

a clear statement that once it has done its job, little of it remains

OR

used in (very) dilute concentrations / small amounts / low doses

3

[15]

17 (a) (i) **M1** **0**

M2 **(+) 5**

Accept Roman V for M2

2

(ii) $I_2 + 10HNO_3 \longrightarrow \mathbf{2}HIO_3 + \mathbf{10}NO_2 + \mathbf{4}H_2O$

Accept multiples

1

(b) **M1** IO_3^- + **6**H^+ + **5**I^- ⟶ **3**I_2 + **3**H_2O

For M1, ignore state symbols

Credit multiples

Accept 2½I_2 + ½I_2 as alternative to 3I_2

Electrons must be cancelled

M2 $NaIO_3$ ***OR*** IO_3^- ***OR*** iodate ions ***OR*** iodate(V) ions etc.

For M2 Do not penalise an incorrect name for the correct oxidising agent that is written in addition to the formula.

Accept "the iodine in iodate ions" but NOT "iodine" alone

Accept "the iodine / I in iodate ions" but NOT "iodine" alone

2

(c) (i) Iodine ***OR*** I_2

Insist on correct name or formula

1

(ii) H_2SO_4 + **6**H^+ + **6**e^- ⟶ S + **4**H_2O

Ignore state symbols

SO_4^{2-} + **8**H+ + **6**e^- ⟶ S + **4**H_2O

Credit multiples

Do not penalise absence of charge on the electron

1

(d) hydrogen sulfide

OR H_2S

OR hydrogen sulphide

1

(e) (i) Ag^+ + I^- ⟶ AgI ONLY

Ignore state symbols

No multiples

1

(ii) The (yellow) precipitate / solid / it does not dissolve / is insoluble

ignore "nothing (happens)"

OR turns to a <u>white solid</u>

ignore "no observation"

OR stays the same

OR no (visible/ observable) change

OR no effect / no reaction

1

(iii) The silver nitrate is acidified to

- react with / remove <u>(an)ions that would interfere</u> with the test

  Ignore reference to "false positive"

- prevent the formation of other <u>silver precipitates / insoluble silver compounds</u> that would interfere with the test

  Do not penalise an incorrect formula for an ion that is written in addition to the name.

- remove (other) <u>ions that react with the silver nitrate</u>

- react with / remove carbonate / hydroxide / sulfite (ions)

  If only the formula of the ion is given, it must be correct

1

(f) (i) An <u>electron donor</u>

Penalise "electron pair donor"

OR (readily) <u>donates / loses / releases / gives (away) electron(s)</u>

Penalise "loss of electrons" alone

Accept "electron donator"

1

(ii) $Cl_2 + \mathbf{2}e^- \longrightarrow \mathbf{2}Cl^-$

Ignore state symbols

Do not penalise absence of charge on electron

Credit $Cl_2 \longrightarrow \mathbf{2}Cl^- - \mathbf{2}e^-$

Credit multiples

1

(iii) For M1 and M2, iodide ions are stronger reducing agents than chloride ions, because

Ignore general statements about Group VII trends or about halogen molecules or atoms. Answers must be specific

M1 Relative size of ions

CE=0 for the clip if "iodine ions / chlorine ions" ***QoL***

Iodide ions / they are larger /have more electron levels(shells) (than chloride ions) / larger atomic / ionic radius

CE=0 for the clip if "iodide ions are bigger molecules / atoms" ***QoL***

OR electron to be lost/outer shell/level (of the iodide ion) is further the nucleus

OR iodide ion(s) / they have greater / more shielding

Insist on iodide ions in M1 and M2 or the use of it / they / them, in the correct context (or chloride ions in the converse argument)

OR converse for chloride ion

M2 Strength of attraction for electron(s)

Must be comparative in both M1 and M2

The electron(s) lost /outer shell/level electron from (an) iodide ion(s) less strongly held by the nucleus compared with that lost from a chloride ion

OR converse for a chloride ion

2

[15]

18 (a) Iodine has more electrons / iodine is bigger (atom or molecule) / iodine has bigger M_r / bigger surface area

1

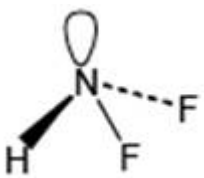
Stronger / more van der Waals forces / vdw / London / temporarily induced dipole / dispersion forces between molecules

1

Stronger VdW intermolecular forces = M2

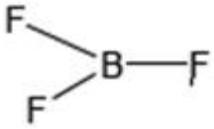
If stated VdW between atoms lose M2

(b) (i)



Mark is for 3 bp and 1 lp attached to N (irrespective of shape)

1



Mark is for 3 bp and 0 lp attached to B (irrespective of shape)

1

NHF_2 shape - pyramidal / trigonal pyramid

Accept tetrahedral / triangular pyramid

1

BF_3 shape - trigonal planar

Not triangular or triangular planar

1

(ii) 107°

Allow 106-108°

1

(c) Hydrogen bonds

Allow H-Bonds

Not just Hydrogen

Apply list principle eg Hydrogen bonding and dipole-dipole = 0

1

(d) Coordinate / dative covalent / dative

If covalent mark on

If ionic / metallic CE = 0

1

Lone pair / both electrons/ 2 electrons on $N(HF_2)$ donated (to BF_3)

Direction of donation needed here

1

[10]

19 (a) $Ca(OH)_2$ OR $Mg(OH)_2$

Ignore name

Could be ionic

1

(b) NaF or sodium fluoride

OR

NaCl or sodium chloride

Either formula or name can score

Do not penalise the spelling "fluoride"

When both formula and name are written,

- *penalise contradictions*
- *if the attempt at the correct **formula** is incorrect, ignore it and credit **correct name** for the mark unless contradictory*
- *if the attempt at the correct name is incorrect, ignore it and credit **correct formula** for the mark unless contradictory*

1

(c) NaClO OR NaOCl

Ignore name (even when incorrect)

The correct formula must be clearly identified if an equation is written

1

(d) **Br_2** (ONLY)

Only the correct formula scores;

penalise lower case "b", penalise upper case "R", penalise superscript

Ignore name

The correct formula must be clearly identified if an equation is written

1

(e) **M1** S OR S_8 OR S_2

M2 I_2 (ONLY)

Ignore names

penalise lower case "i" for iodine,

penalise superscripted numbers

Mark independently

The correct formula must be clearly identified in each case if an equation is written

2

(f) (i) $CH_3CH_2CH=CH_2$

Structure of but-1-ene. Ignore name

Credit "sticks" for C-H bonds

1

(ii) $CH_3CH_2CH_2CH_2OH$

Structure of butan-1-ol. Ignore name

Credit "sticks" for C-H bonds

1

(iii) $CH_3CH_2CH_3$

Structure of propane. Ignore name

Ignore calculations and molecular formula

Credit "sticks" for C-H bonds

Ignore the molecular ion

1

(iv) CH_3CH_2Br OR $C_2H_5B_r$

Structure of bromoethane.

Ignore name and structure of nitrile

Credit "sticks" for C-H bonds

1

[10]

20 (a) (i) **M1** (yellow precipitate is) silver iodide OR AgI (which may be awarded from the equation)

M2 $Ag^+ + I^- \longrightarrow AgI$ (Also scores M1 unless contradicted)

M3 sodium chloride OR NaCl

For M2

Accept multiples

Ignore state symbols

Allow crossed out nitrate ions, but penalise if not crossed out

3

(ii) The silver nitrate is acidified to

- react with / remove ions that would interfere with the test
- prevent the formation of other silver precipitates / insoluble silver compounds that would interfere with the test
- remove (other) ions that react with the silver nitrate
- react with / remove carbonate / hydroxide / sulfite (ions)

Ignore reference to "false positive"

1

(iii) **M1 and M2 in either order**

M1 Fluoride (ion) OR F

M2 • Silver fluoride / AgF is soluble / dissolves (in water)

• no precipitate would form / no visible /observable change

Do not penalise the spelling "fluoride",

Penalise "fluride" once only

Mark M1 and M2 independently

2

(b) **M1** $Ba^{2+} + SO_4^{2-} \longrightarrow BaSO_4$

(or the ions together)

M2 white precipitate / white solid / white suspension

M3 Barium meal or (internal) X-ray or to block X-rays

M4 $BaSO_4$ / barium sulfate is insoluble (and therefore not toxic)

For M1, ignore state symbols

Allow crossed out sodium ions, but penalise if not crossed out

For M2, ignore "milky"

If $BaSO_3$ OR BaS used in M1 and M4, penalise once only

For M3 Ignore radio-tracing

For M4 NOT barium ions

NOT barium

NOT barium meal

NOT "It" unless clearly $BaSO_4$

4

(c) **M1** **2**(12.00000) + **4**(1.00794) = 28.03176

M2 Ethene and CO or "they" have an imprecise $\mathbf{M_r}$ of 28.0 / 28

OR

Ethene and CO or "they" have the same M_r to one d.p.

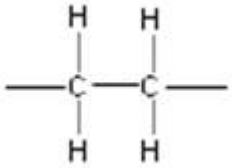
OR

These may be shown by two clear, simple sums identifying both compounds

M3 $C_2H_4 + \mathbf{2}O_2 \longrightarrow \mathbf{2}CO + \mathbf{2}H_2O$

($H_2C{=}CH_2$)

M4 Displayed formula



M5 Type of polymer = Addition (polymer)

M1 must show working using 5 d.p.for hydrogen

Penalise "similar" or "close to", if this refers to the imprecise value in M2, since this does not mean "the same"

For M3, accept $CH_2{=}CH_2$ OR CH_2CH_2

For M4, all bonds must be drawn out including those on either side of the unit.

Penalise "sticks"

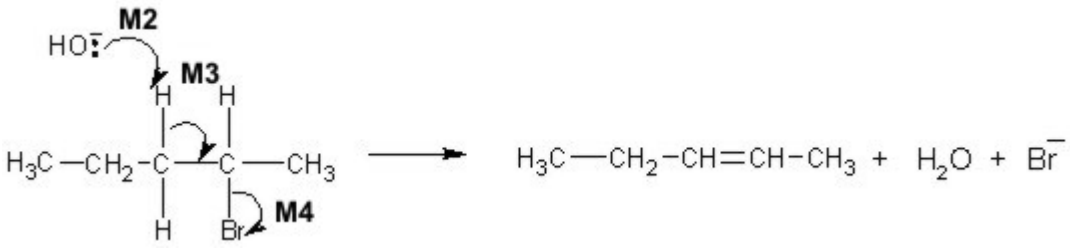
*Ignore brackets around **correct** repeating unit but penalise "n"*

Penalise "additional"

5

[15]

21 (a) (i) **M1** Elimination



M2 must show an arrow from the <u>lone pair on the oxygen</u>
of a negatively charged hydroxide ion <u>to a correct</u> H atom

M3 must show an arrow from a C-H bond adjacent to
the C-Br bond towards the appropriate C-C bond.
Only award if a reasonable attempt has been made
at the attack on the H atom of the appropriate adjacent C-H

M4 is independent provided it is from their <u>original molecule</u>

Award full marks for an E1 mechanism in which **M3** is on the correct carbocation.

N.B. These are double-headed arrows

For M1, accept "Base elimination" but <u>no other prefix</u>.

*Penalise **M2** if covalent KOH*

*Penalise **M4** for formal charge on C of C-Br or incorrect partial charges on C-Br*

Ignore other partial charges

Penalise once only in any part of the mechanism for a line and two dots to show a bond.

*<u>Max any 2 of 3 marks **for the mechanism**</u> for wrong reactant (or wrong product if shown).*

Accept the correct use of "sticks" for the molecule except for the C-H being attacked

4

(ii) **Structure for pent-1-ene**

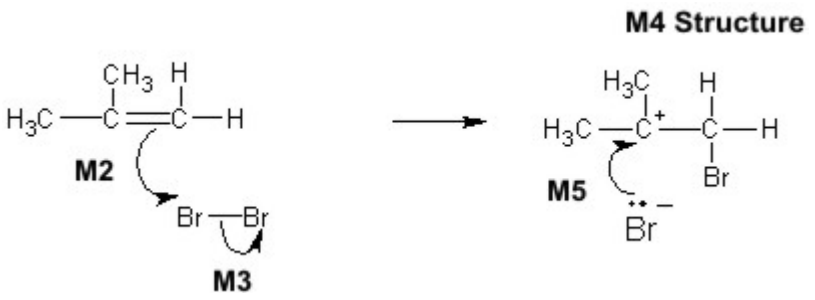
$CH_3CH_2CH_2CH=CH_2$

Penalise C_3H_7

Accept correct "sticks"

1

(b) **M1 <u>Electrophilic addition</u>**



M2 must show an arrow from the double bond towards the Br atom of the Br-Br molecule

M3 must show the breaking of the Br-Br bond.

M4 is for the structure of the tertiary carbocation with Br on the correct carbon atom.

M5 must show an arrow from the lone pair of electrons on the negatively charged bromide ion towards the positively charged carbon atom.

N.B. These are double-headed arrows

For M1, both words required.

For the mechanism

M2 *Ignore partial negative charge on the double bond.*

M3 *Penalise partial charges on Br-Br bond if wrong way and penalise formal charges*

Penalise once only in any part of the mechanism for a line and two dots to show a bond

Max any 3 of 4 marks ***for the mechanism*** *for*

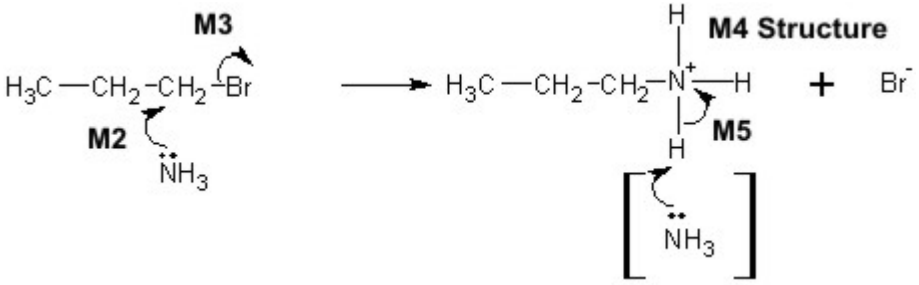
wrong organic reactant or wrong organic product (if shown) or primary carbocation.

If HBr is used, max 2 marks ***for their mechanism***

Accept the correct use of "sticks"

5

(c) **M1 Nucleophilic substitution**



M2 must show an arrow from the lone pair of electrons on the nitrogen atom of an ammonia molecule to the C atom.

M3 must show the movement of a pair of electrons from the C-Br bond to the Br atom. **M3** is independent provided it is from their original molecule

M4 is for the structure of the alkylammonium ion, which could be a condensed formula. A positive charge must be shown on/or close to, the N atom.

M5 is for an arrow from the N-H bond to the N atom.

Award full marks for an S_N1 mechanism in which M2 is the attack of the ammonia on the intermediate carbocation.

N.B. These are double-headed arrows

*For **M1**, both words required.*

*Penalise **M2** if NH_3 is negatively charged.*

*Penalise **M3** for formal charge on C or incorrect partial charges*

The second mole of ammonia is not essential for M5; therefore ignore any species here.

Penalise once only for a line and two dots to show a bond.

*Max any 3 of 4 marks **for the mechanism** for wrong organic reactant (or wrong organic product if shown)*

Accept the correct use of "sticks"

5

[15]

22 (a) Hydrochloric acid = **C**

1

Barium chloride = **A**

1

(b) Barium sulfate is insoluble

1

$CuSO_4 + BaCl_2 \rightarrow BaSO_4 + CuCl_2$

Accept multiples.

Accept ionic equation.

Do not penalise lack of state symbols, but if used they must be correct.

1

(c) CO_2 / Carbon dioxide

1

(d) Reagent 1 silver nitrate (solution)

Ignore lack of reference to acidifying prior to addition of silver nitrate solution.

1

Observation 1 White precipitate

1

Reagent 2 (dilute) ammonia solution / aqueous ammonia

*Do not accept addition of **ammonia** only.*

1

Observation 2 (Colourless) solution

Allow ppt dissolves.

Do not allow 'goes colourless' or 'goes clear'.

Chlorine and no visible change or solution does not become orange scores M3 and M4.

1

(e) Gloves / wash hands after use

Ignore 'eye protection'.

Do not accept 'do not ingest the chemicals', 'wipe up spillages', 'use a fume cupboard', 'wear a lab coat' (list principle).

1

[10]

23 (a) To ensure that other (an)ions do not interfere

Accept 'to prevent other salts precipitating'.

Accept 'to remove carbonate / hydroxide (ions)'.

1

(b) <u>Concentrated</u> (ammonia)

'Precipitate partially soluble in dilute ammonia' scores both marks.

1

Precipitate soluble / dissolves

1

[3]

24 (a) (i) Green

Ignore shades of green.

1

(ii) <u>Excess</u> acidified potassium dichromate(VI)

1

Reflux (for some time)

1

In the diagram credit should be given for

- a vertical condenser

Lose M3 and M4 for a distillation apparatus.

1

- an apparatus which would clearly work

Do not allow this mark for a flask drawn on its own.

Penalise diagrams where the apparatus is sealed.

1

(iii) Distillation

1

Immediately (the reagents are mixed)

1

(b) Keep away from naked flames

Allow heat with water-bath or heating mantle.

If a list is given ignore eye protection, otherwise lose this mark.

1

(c) (i) Tollens' or Fehling's reagents

*Incorrect reagent(s) loses **both** marks.*

Accept mis-spellings if meaning is clear.

1

Silver mirror / red ppt. formed

Accept 'blue to red' but not 'red' alone.

1

(ii) Sodium carbonate (solution) / Group II metal

Allow indicator solutions with appropriate colours.

Accept any named carbonate or hydrogen carbonate.

1

Effervescence / evolves a gas

Accept 'fizzes'.

1

(d) Propanoic acid

If this mark is lost allow one mark if there is reference to stronger intermolecular forces in the named compound.

Lose M1 and M3.

1

Contains hydrogen bonding

1

Some comparison with other compounds explaining that the intermolecular forces are stronger in propanoic acid

1

[15]

25 (a) (ligand) substitution

Allow 'ligand exchange'.

1

(b) To displace the equilibrium to the right

To ensure reaction goes to completion.

1

To improve the yield

Allow 'to replace all chlorines'.

1

(c) (i) $K_2PtCl_4 + 4KI \rightarrow K_2PtI_4 + 4KCl$

Allow correct ionic equations $PtCl_4^{2-} + 4I^- \rightarrow PtI_4^{2-} + 4Cl^-$

Allow multiples and fractions.

1

(ii) = (780.9) × 100 / (415.3 + 664)

Working must be clearly shown.

Allow one mark for correct relationship even if M_r values are incorrect eg using values from ionic equation.

1

= 72.4

Allow 72%

1

(d) (i) $Ag^+ + I^- \rightarrow AgI$

Ignore state symbols even if incorrect.

This equation only.

1

(ii) Stops the reverse reaction / equilibrium displaced to the right

1

(e) Number of steps in the process

Allow 'equilibrium may lie on the reactant side' / side reactions / isomer formation.

1

Losses at each stage of the synthesis

Equilibrium losses or practical losses or yield not 100% for each step.

1

(f) Minimum amount of hot solvent

Accept 'small' for minimum.

Accept water.

1

Cool / crystallise

1

Filter

1

(g) (i) Small amounts are more likely to kill cancer cells rather than the patient

1

(ii) Wear gloves / wash hands after use

Ignore masks.

Apply the list principle if more than one answer.

1

[15]

26 (a) (i) MnO_2 (+) 4

1

(ii) $MnO_2 + \mathbf{4}H^+ + \mathbf{2}e^- \longrightarrow Mn^{2+} + \mathbf{2}H_2O$

Or multiples

Ignore state symbols

Credit electrons subtracted from RHS

Ignore absence of charge on e

1

(iii) Iodide ion(s) is/are oxidised because they have <u>lost electron(s)</u>

Do not penalise reference to iodine; the mark is for electron loss

1

(b) (i) **M1** Cl_2 0

M2 HClO (+) 1

2

(ii) **M1** Equilibrium will shift/move <u>to the right</u>

OR <u>L to R</u>

OR to favour the <u>forward reaction</u>

OR to produce <u>more HClO</u>

M2 **<u>Consequential on correct M1</u>**

To <u>oppose the loss of HClO</u>

OR <u>replaces the HClO</u> (that has reacted)

for M2

NOT just "to oppose the change"

2

(c) (i) The answers can be in **<u>either order</u>**

M1 $\mathbf{2}Br^- \longrightarrow Br_2 + \mathbf{2}e^-$

M2 $\mathbf{4}H^+ + SO_4^{2-} + \mathbf{2}e^- \longrightarrow SO_2 + \mathbf{2}H_2O$

OR

$\mathbf{2}H^+ + H_2SO_4 + \mathbf{2}e^- \longrightarrow SO_2 + \mathbf{2}H_2O$

NOT multiples

Ignore state symbols

Credit electrons subtracted from incorrect side

Ignore absence of charge on e

2

(ii) $KCl + H_2SO_4 \longrightarrow KHSO_4 + HCl$

OR

$\mathbf{2}KCl + H_2SO_4 \longrightarrow K_2SO_4 + \mathbf{2}HCl$

Credit ionic equations

1

(iii) For M1 and M2, chloride ions are weaker reducing agents than bromide ions, because

M1 Relative size of ions

Chloride ions are <u>smaller</u> than bromide ions OR chloride ion electron(s) are <u>closer</u> to the nucleus OR chloride ion has fewer (electron) shells/levels OR chloride ion has less shielding (or converse for bromide ion)

M2 Strength of attraction for electron being lost

Outer shell/level electron(s) OR electron(s) lost from a chloride ion is more strongly held by the nucleus compared with that lost from a bromide ion (or converse for bromide ion)

If the forces are described as intermolecular or Van der Waals then CE = 0

Ignore general reference to Group 7 trend

For M1 accept reference to chlorine/bromine or reference to atoms of these but NOT "chloride/bromide atoms" or "chlorine/bromine molecules"

For M2 insist on reference to the correct ions

This is the expected answer, but award credit for a candidate who gives a correct explanation in terms of hydration enthalpy, electron affinity and atomisation enthalpy.

2

[12]

27 (a) (i) **M1 Initiation**

$Cl_2 \longrightarrow 2Cl\bullet$

M2 First propagation

$Cl\bullet + CH_3CH_3 \longrightarrow \bullet CH_2CH_3 + HCl$

C_2H_6

M3 Second propagation

$Cl_2 + \bullet CH_2CH_3 \longrightarrow CH_3CH_2Cl + Cl\bullet$

C_2H_5Cl

M4 Termination (must make C_4H_{10})

$2 \bullet CH_2CH_3 \longrightarrow C_4H_{10}$ or $CH_3CH_2CH_2CH_3$

Penalise absence of dot once only.

Penalise + or – charges every time

Penalise incorrect position of dot on ethyl radical once only.

Penalise $C_2H_5\bullet$ once only

Accept $CH_3CH_2\bullet$ with the radical dot above/below/to the side of the CH_2

Mark independently

4

(ii) **M1** ultra-violet/uv/sun light

OR (very) high temperature OR 500 °C ≥ T ≤1000 °C

M2 (free-)radical substitution

Ignore "heat" for M1

Both words needed for M2

For M2, ignore the word "mechanism"

2

(b) (i) $Cl_2 + H_2O \longrightarrow HClO + HCl$

OR

$Cl_2 + H_2O \longrightarrow 2H^+ + ClO^- + Cl^-$

Accept HOCl or ClOH

Accept other ionic or mixed representations

Ignore state symbols

1

(ii) **M1** Any one from
- in swimming pools
- in drinking water
- to sterilise/disinfect/sanitise water
- in water treatment

Ignore the manufacture of bleach
Ignore "to clean water"
Ignore "water purification"

M2 The (health) benefit outweighs the risk or wtte
OR a clear statement that once it has done its job, little of it remains OR used in (very) dilute concentrations/ small amounts/low doses

Mark independently but M1 can score from (M2) explanation

2

(iii) Sodium chlorate(I) or sodium hypochlorite

Must be named

Ignore (in)correct formulae

Insist on the (I) in the name

1

(c) (i) $Cl_2 + \mathbf{2}Br^- \longrightarrow Br_2 + \mathbf{2}Cl^-$

Or half this equation

Ignore state symbols

1

(ii) **M1 The relative size (of the molecules/atoms)**

Bromine is larger than chlorine OR has more electrons/electron shells

OR It is larger/It has a larger atomic radius/it is a larger molecule/atom

M2 How size of the intermolecular force affects energy needed

The forces between bromine/Br_2 molecules are stronger (than the forces between chlorine/Cl_2 molecules leading to more energy needed to separate the molecules) (or converse)

OR bromine/Br_2 has stronger/more (VdW) intermolecular forces.

(or converse)

For M1 ignore whether it refers to molecules or atoms.

CE = 0 for reference to (halide) ions

Ignore molecular mass

QoL *for clear reference to the difference in size of the force between molecules*

Penalise M2 if covalent bonds are broken

2

[13]

28 (a) Correct completion of table

(7.2 – 9.4 – 10.3 – 11.5 – 12.2 – 13.1)

Any error loses the mark.

1

Appropriate scales for axes

No penalty for missing labels but the graph must cover at least half of the available area.

1

All points plotted correctly

Allow ±1 small square.

1

Line of best fit acceptable

Must be a reasonably smooth curve but make allowance for freehand drawing passing within one small square of each point.

Do not penalise minor doubling of line.

1

(b) Maximum mass at (44.0 / 4) = 11.0 g
giving a max. pressure of 1.7 ± 0.1 MPa

Allow this pressure range only.

Check that candidate's answer matches graph.

1

(c) 7.2 g of NaCl in 250 cm^3 represents 28.8 g dm^{-3}

Allow 0.49 but not 0.5; otherwise do not penalise precision of answer

1

Molarity = 0.492 mol dm^{-3}

Conseq. to their graph value for 100 kPa to 2 or 3 sig.

1

(d) Measuring cylinder = (1 / 250) × 100 = 0.4%
Balance = (0.1 / 7.2) × 100 = 1.4%

Both values correct for the first mark.

Balance error conseq. on their 100 kPa mass value.

Ignore precision of answers.

1

Combined error 1.8%

*When error being calculated is **not** stated, allow **if** the calculations are in the same order as in the question (measuring cylinder, balance).*

If only combined error given then 1 mark only.

1

(e) (i) The points are good enough to be able to draw a smooth curve because the line passes through / close to all points.

Mark consequentially on candidate's graph

1

(ii) There are no anomalous points

Mark consequentially on candidate's graph

1

(f) The experiment only seeks an approximate figure for the maximum pressure

Allow words to that effect.

1

(g) (i) Toxic (to marine life)

Allow phrasing which implies a detrimental effect on marine ecology.

1

(ii) Mixing the effluent with (sea) water to dilute it

Penalise any method which removes the salt or which implies storage.

1

(h) $2Br^- + Cl_2 \rightarrow 2Cl^- + Br_2$

Allow NaBr or KBr

1

(i) The cost of removing water / heating would be too high

Discount answers based on toxicity or speed of reaction.

Allow answers based on cost of using sulfuric acid.

1

(j) (i) Carbon

Allow C, soot, graphite, coal.

1

(ii) Formed by the decomposition of organic material / living organisms in the sea water

Allow 'erosion of coal beds'.

1

(iii) Dissolve the solid formed in water

Do not allow melting of the solid.

1

Filter off the insoluble particles

1

(k) $Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$

Allow $Ca(OH)_2 + 2H^+ \rightarrow Ca^{2+} + 2H_2O$

Allow multiples.

1

(l) In agriculture / to raise the pH of soil / (Lime-based) mortars in construction

Allow words to that effect.

1

[22]

29 (a) NaBr ONLY

Penalise incorrect case or additional formulae.
Ignore names

1

(b) NaF ONLY

Penalise incorrect case or additional formulae.
Ignore names

1

(c) <u>ONLY one</u> from either
NaF

OR

NaCl

Penalise incorrect case or additional formulae.
Ignore names

1

(d) NaI ONLY

Penalise incorrect case or additional formulae.
Ignore names

1

[4]

30

(a) **M1** Cl_2 (provides the pale green colour)

M1 <u>requires the formula</u>

M2 NaOH reacts with the acid(s)/the HCl/the HClO/H^+

Ignore "reacts with the products"

Ignore "reacts with chloride ion"
Ignore "reacts with chlorine"

M3 <u>requires a correct answer in M2</u>
Equilibrium shifts (from left) <u>to right</u> ***OR*** wtte

3

(b) **M1** A reducing agent is an <u>electron donor</u> OR (readily) <u>loses/ gives away electrons</u>

Penalise M1 if "electron pair donor"

M2 $Cl_2 + \mathbf{2}e^- \rightarrow \mathbf{2}Cl^-$

For M3 and M4, **i**odide ions are stronger reducing agents than chloride ions, because

Ignore state symbols in M2 Accept no charge on the electron
Credit the electrons being lost on the RHS

M3 Relative size of ions/atomic radius/ionic radius
<u>Iodide ions</u> are <u>larger</u>/have more (electron) shells/levels than chloride ions (or converse for chloride ion) OR <u>electron(s) to be lost/outer shell/level</u> is <u>further</u> from the nucleus (or converse for chloride ion) OR greater/more shielding

For M3 insist on "<u>iodide ions</u>"

M4 Strength of attraction for <u>electron(s) being lost</u>

<u>Electron(s) lost</u> from an iodide ion is <u>less strongly held by the nucleus</u> compared with that lost from a chloride ion

M3 and M4 must be comparative and should refer to electrons.

(assume argument refers to iodide ions but accept converse argument for chloride ions)

4

(c) **M1** $\mathbf{2}Cl_2 + \mathbf{2}H_2O \rightarrow \mathbf{4}HCl + O_2$

Or multiples

M2 silver chloride ONLY

<u>M2 requires a name</u>

M3 The solid/precipitate would dissolve
OR is soluble
OR (It) forms a (colourless) solution

Mark M3 independently

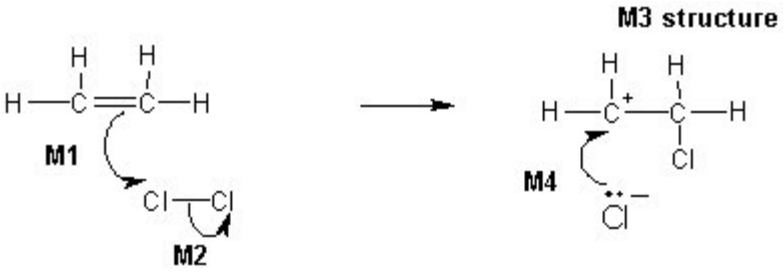
Ignore "disappears"

3

(d) Electrophilic addition

1

Mechanism:



M2 Penalise partial charges if wrong way around, otherwise ignore

*Max 3 marks **for the mechanism** for wrong reactant and/or "sticks" (wrong reactant could be HBr or Br_2 or incorrect alkene)*

M1 must show an arrow from the double bond towards one of the Cl atoms on a Cl–Cl molecule.

M2 must show the breaking of the Cl–Cl bond.

M3 is for the structure of the carbocation with Cl substituent.

M4 must show an arrow from the lone pair of electrons on a negatively charged chloride ion towards the positively charged carbon atom.

4

[15]

31 (a) Hydrochloric acid contains chloride ions / Cl^-

OR

Chloride ions / Cl^- (in the acid) would react

OR

Chloride ions / Cl^- would interfere with the test

OR

Would form a (white) precipitate

OR

Would form insoluble AgCl

QoL

If a precipitate colour is given it must be white

1

(b) **M1** No precipitate
OR
Colourless solution
OR
No change.

1

Ignore "nothing"

M2 Silver fluoride / AgF is soluble (in water)

Do not penalise the spelling "flouride"

1

(c) **M1** Yellow precipitate
OR
Yellow solid

Both words needed for M1
Ignore "pale" as a prefix before "yellow"

1

M2 $Ag^+ + I^- \rightarrow AgI$

Ignore state symbols
Allow crossed out nitrate ions, but penalise if not crossed out

1

[5]

32 (a) sulfuric acid / H_2SO_4

1

(b) hydriodic acid / HI **OR** hydrobromic acid / HBr

1

(c) add **dilute** ammonia solution

Notes
* *do not allow 'concentrated ammonia' or 'ammonia '*

1

precipitate / ppt disappears / dissolves **OR** colourless solution forms

1

(d) would react with the acid / no gas evolved in tests

1

[5]

33

Mark Range	The marking scheme for this part of the question includes an overall assessment for the Quality of Written Communication (QWC). There are no discrete marks for the assessment of QWC but the candidates' QWC in this answer will be one of the criteria used to assign a level and award the marks for this part of the question **Descriptor** an answer will be expected to meet most of the criteria in the level descriptor
4-5	– claims supported by an appropriate range of evidence – good use of information or ideas about chemistry, going beyond those given in the question – argument well structured with minimal repetition or irrelevant points – accurate and clear expression of ideas with only minor errors of grammar, punctuation and spelling
2-3	– claims partially supported by evidence – good use of information or ideas about chemistry given in the question but limited beyond this – the argument shows some attempt at structure – the ideas are expressed with reasonable clarity but with a few errors of grammar, punctuation and spelling
0-1	– valid points but not clearly linked to an argument structure – limited use of information or ideas about chemistry – unstructured – errors in spelling, punctuation and grammar or lack of fluency

(a) Kills bacteria / prevents bacterial diseases QWC

1

Chlorine is a toxic substance

1

$Cl_2 + H_2O \rightarrow HCl + HClO$

1

(b) $Cl_2(aq)$ to $Br^-(aq)$; yellow-orange or yellow-red or QWC
yellow-brown solution

1

$2Br^- + Cl_2 \rightarrow 2Cl^- + Br_2$
or molecular equation

1

$Cl_2(aq)$ to $I^-(aq)$; brown/black solution formed or QWC
black/brown/grey ppt/solid

1

$2I^- + Cl_2 \rightarrow 2Cl^- + I_2$
or molecular equation

1

(c) Bromide: Brown/orange fumes

1

Bromine produced

1

Sulphur dioxide produced

1

Iodide: Purple fumes or black/brown/grey solid QWC
or smell of bad eggs

1

Iodine produced

1

SO_2, S, H_2S produced (one mark each)

3

Half-equations $2Br^- \rightarrow Br_2 + 2e^-$1
OR $2I^- \rightarrow I_2 + 2e^-$

1

$H_2SO_4 + 2e^- + 2H^+ \rightarrow SO_2 + 4H_2O$
OR $H_2SO_4 + 6e^- + 6H^+ \rightarrow S + 4H_2O$
OR $H_2SO_4 + 8e^- + 8H^+ \rightarrow H_2S + 4H_2O$

1

Overall equation Any correct equation based on half-equations QWC

1

[18]

34 (a) Reduction involves gain of electrons (1)

A reducing agent loses (donates) electrons (1)

2

(b) (i) Sulphur dioxide (1)

oxidation state +4 (1)

Sulphur (1)

oxidation state 0 (1)

Hydrogen sulphide (1)

oxidation state – 2 (1)

6

(ii) Sulphur dioxide is a choking gas or has a pungent odour (1)

Sulphur is a yellow solid (1)

Hydrogen sulphide has a smell of bad eggs (1)

Any 2 marks

2

(iii) $SO_4^{2-} + 4H^+ + 2e^- \rightarrow SO_2 + 2H_2O$ (1)

$SO_4^{2-} + 8H^+ + 6e^- \rightarrow S + 4H_2O$ (1)

$SO_4^{2-} + 10H^+ + 8e^- \rightarrow H_2S + 4H_2O$ (1)

Any 2 marks

(Allow equations with H_2SO_4)

2

(c) $Cl_2 + H_2O \rightarrow H^+ + Cl^- + HOCl$

or $Cl_2 + H_2O \rightarrow 2H^+ + Cl^- + OCl^-$

or $Cl_2 + H_2O \rightarrow HCl + HOCl$ (1)

Water is not oxidised (1)

The oxidation states of O (–2) and H (+1) remain unchanged (1)

3

[15]

35 D

[1]

36 (a) decreases

1

number of shells increases/ shielding increases /atomic size increases

weaker attraction (by nucleus) on bonding electrons / weaker attraction (by nucleus)

1

on electron pair in a covalent bond

1

(b) (i) increases

1

(ii) concentrated sulphuric acid

1

(c) white ppt

1

soluble in ammonia

1

cream ppt

1

partially soluble /insoluble in ammonia

1

(d) $Cl_2 + 2NaOH \rightarrow NaCl + NaOCl + H_2O$

1

bleach

1

disinfectant /steriliser/kills bacteria

1

[12]

37 (a) decreases;

1

increase in shielding ;

1

(or atomic radius)
less attraction for bonding *(or shared)* electrons;

1

(b) brown solution;

1

(or black solid)
$Cl_2 + 2KI \rightarrow 2KCl + I_2$;

(or ionic equation)

1

(c) SO_2;

1

$SO_4^{2-} + 4H^+ 2e^- \rightarrow SO_2 + 2H_2O$;

1

S (also H_2S);

1

$SO_4^{2-} + 8H^+ 6e^- \rightarrow S + 4H_2O$ (or $SO_4^{2-} + 10H^+ + 6e^- \rightarrow H_2S + 4H_2O$)

1

(d) $Cl_2 + 2NaOH \rightarrow NaCl + NaOCl + H_2O$;

1

sodium chloride;

1

–1;

1

sodium chlorate(I) (or bleach etc);

1

+1;

1

[14]

38 (a) (i)

	The addition of $AgNO_3$	followed by concentrated NH_3(aq)
Observation with NaBr(aq)	Cream or off white precipitate or solid (1)	Precipitate dissolves (1)
Observation with NaI(aq)	Yellow precipitate or solid (1)	Precipitate insoluble or no change (1)

(ii) Ag F is soluble;

5

(b) (i) identity: $[Ag(S_2O_3)_2]^{3-}$;

1

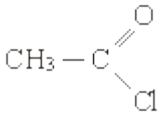
(ii) equation: $AgI + 2S_2O_3^{2-} \rightarrow [Ag(S_2O_3)_2]^{3-} + I^-$

1

(iii) use: in photography or as a fixer;

1

(c) (i) Structure

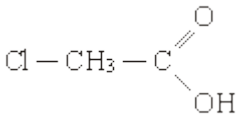


1

Observation: Vigorous or violent or exothermic reaction
or fumes or white precipitate formed immediately

1

(ii) Structure:



1

Observation: No immediate precipiate or reaction

OR

white precipitate formed very slowly;

1

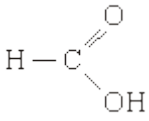
(d) (i) Silver-containing complex: $[Ag(NH_3)_2]^+$;

1

Shape: Linear;

1

(ii) Structure



1

Explanation: Methanoic acid contains an aldehyde group;

1

(iii) H_2CO_3 or CO_2 or $OC(OH)NH_2$ or $(NH_2)_2CO$ or $(NH_4)_2CO_3$

OR

$HCOONH_4$;

1

[17]

39 B

[1]

40 D

[1]

41 (a) Increase

1

Van der Waal's forces between molecules

1

Increase with size (or M_r or surface area etc)

1

More energy needed to break (overcome) these forces

(Note max 2 from last three marks if no mention of molecules or 'molecular')

1

(b) (i) Brown solution (or yellow or orange)

1

$Cl_2 + 2Br \rightarrow 2C1^- + Br_2$

1

(ii) cream precipitate

1

$Br^- + Ag^+ \rightarrow AgBr$

1

Precipitate dissolves

1

(iii) orange (brown) fumes (gas), White fumes (or misty fumes), choking gas (any 2)

2

(c) $2H^+ + H_2SO_4 + 2Br^- \rightarrow SO_2 + Br_2 + 2H_2O$ (SO_2 and Br_2 (1), equation (1))

2

[13]

42 (a) Gains electrons (or removes electrons)

1

(b) (i) +4

1

+6

1

(ii) $Br_2 + 2e^- \rightarrow 2Br^-$

1

(iii) $SO_2 + 2H_2O \rightarrow 4H^+ + SO_4^{2-} + 2e^-$

1

(iv) $Br_2 + SO_2 + 2H_2O \rightarrow 2Br^- + 4H^+ + SO_4^{2-}$

1

(c) $Cl_2 + H_2O \rightarrow H^+ + Cl^- + HOCl$

1

Chloride: –1

1

Chlorate(I): +1

1

(d) Chloride ions cannot reduce sulphuric acid

(Or chloride ions are weak reducing agents
Or sulphuric acid is not a strong enough oxidising agent
Or sulphuric acid is a weaker oxidising agent than chlorine)

1

(e) $KCl + H_2SO_4 \rightarrow HCl + KHSO_4$

(Allow $2KCl + H_2SO_4 \rightarrow 2HCl + K_2SO_4$)

1

(f) (i) Bromine

1

(ii) Sulphur dioxide

1

[13]

43 (a) increases from fluorine to iodine **(1)**

sizes of molecules increase **(1)**
(or molecules have more electrons or mass of molecules increases)

QoL mark

Magnitude of intermolecular forces or vdW forces increase **(1)** (or more vdW forces)

More energy required to separate molecules (or particles) **(1)**
(or more energy to break intermolecular forces)
or intermolecular forces difficult to break

4

(b) with NaCl white ppt **(1)**
soluble in ammonia **(1)**

note, if ppt clearly refers to wrong substance
e.g. NaCl then C.E = 0

with NaBr cream (or off white or biege) ppt **(1)**
partially soluble (or insoluble) in ammonia **(1)**

ignore references to conc ammonia

if obviously added silver nitrate mixed with ammonia allow:
*NaCl: no change **(2)***
*NaBr: cream ppt **(2)***

4

(c) oxidising ability decreases from chlorine to iodine (or down the Group) **(1)**

$Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$ **(1)**

allow use of NaBr, HBr etc

Br_2 red brown (or yellow or orange) liquid (or solution but not solid) **(1)**

$Cl_2 + 2I^- \rightarrow 2Cl^- + I_2$ **(1)**

allow use of NaBr etc, penalise HI once only

I_2 brown solution / black solid **(1)**

do not allow any reference to purple

$Br_2 + 2I^- \rightarrow 2Br^- + I_2$ **(1)**

Yellow/orange/red-brown/brown solution goes brown/darker
brown solution/black solid **(1)**

7

[15]

44 (a) *Trend*: decrease **(1) C.E if wrong**
Explanation: number of shells increases (or atomic radius increases) **(1)**
increased nuclear shielding **(1)**
or less attraction for bond (pair electrons)

3

(b) (i) *Observation*: brown solution or black solid **(1)**

purple wrong

Equation: $Br_2 + 2I^- \rightarrow I_2 + 2Br^-$ **(1)**

Allow NaI, KI

(ii) Br_2 is a weaker oxidising agent than Cl_2 **(1) (or converse)**

3

OR Br_2 is less reactive than Cl_2

penalise Cl, Br, Cl^-, Br^- etc

(c) *Observation with KF (aq)*: no change **(1) (or colourless)**
Observation with KBr(aq): cream/off white <u>ppt</u> **(or solid) (1)**

2

(d) $KF + H_2SO_4 \rightarrow KHSO_4 + HF$ **(1)**

or $2\ KF + H_2SO_4 \rightarrow K_2HSO_4 + 2\ HF$

Allow ions

1

(e) $2\ H_2SO_4 + 2\ Br^- \rightarrow \underline{SO_2 + Br_2} + 2\ H_2O + SO_4^{2-}$ **(1)**
Balanced equation **(1)**

Allow $2\ H_2SO_4 + 2\ NaBr \rightarrow SO_2 + Br_2 + 2\ H_2O + Na_2SO_4$
$H_2SO_4 + 2\ HBr \rightarrow 2\ H_2O + Br_2 + SO_2$ etc

2

[11]

45 (a) (i) –2 OR 2–

(ii) NaI or NaAt or I^- or iodide or At^-or Astatide **(1)**

<u>Not</u> atoms or molecules

(iii) Smell of bad eggs **(1)**

Allow $PbAc_2$ goes black and $K_2Cr_2O_7/H^+$ goes cloudy green

(iv) $8\ e^- + 8\ H^+ + H_2SO_4 \rightarrow H_2S + 4H_2O$ **(1)**

OR $10\ H^+ + SO_4^{2-}$

4

(b) (i) HF or HCl **(1)**

CE = 0 if redox answer given

If wrong halide given allow max one in b(iii)

If NaF or NaCl, or F^- or Cl^- given lose mark in (i)

Mark on if X is e.g. HF_2 or H_2F

(ii) NaF or NaCl or F^- or Cl^- **(1)**

(iii) A proton donor or an acid **(1)**

(iv) $H^+ + F^- \rightarrow HF$

OR $H_2SO_4 + NaF \rightarrow NaHSO_4 + HF$

OR $H_2SO_4 + 2\ NaF \rightarrow Na_2SO_4 + 2\ HF$

OR for chloride

4

[8]

46 (a) (i) HNO_3 or CH_3COOH **(1)**

CE in (a) if incorrect acid given

(ii) $2HNO_3 + Na_2CO_3 \rightarrow 2NaNO_3 + CO_2 + H_2O$ **(1)**

OR $2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$

Not H_2CO_3

2

(b) (i) I^- or At^- not elements, atoms or molecules **(1)**

(ii) F^- not elements, atoms or molecules **(1)**

2

(c) (i) Cl^- **(1)**

Allow AgCl Not element, atoms or molecules

(ii) Br^- **(1)**

Allow AgBr Not element, atoms or molecules

2

[6]

47 C

[1]

48 D

[1]

49 A

[1]

50 D

[1]

51 (a) (i) Halides:- Fluoride
Chloride **(1)**

Equation:- $H^+ + F^- \rightarrow HF$ *(or molecular / for a correct halide)* **(1)**

(ii) Halides:- Bromide and iodide **(1)**

Equation:- H_2SO_4 *(or* $2H^+ + SO_4^{2-}$*)* $+ 2H^+ + 2e^- \rightarrow SO_2 + 2H_2O$ **(1)**

$2Br^- \rightarrow Br_2 + 2e^-$ **(1)**

$H_2SO_4 + 2H^+ + 2Br^-$ (or 2HBr) $\rightarrow Br_2 + SO_2 + 2H_2O$ **(1)**

Q of L penalise wrong symbol for fluoride or bromide once
Ignore state symbols in equations

(iii) Products Sulphur (or S_8 not S_4) **(1)**
Hydrogen sulphide **(1)**

Equation:- H_2SO_4 *(or* $2H^+ + SO_4^{2-}$*)* $+6H^+ + 6e^- \rightarrow S + 4H_2O$ **(1)**

OR

H_2SO_4 *(or* $2H^+ + SO_4^{2-}$*)* $+ 8H^+ + 8e^- \rightarrow H_2S + 4H_2O$

9

Ignore halide if given even if incorrect
Do not allow elements, molecules or atoms in part (a)

(b) Addition of silver nitrate
Chloride gives white precipitate / solid **(1)**
Bromide gives cream precipitate / solid **(1)**
Iodide gives yellow precipitate / solid **(1)**

Addition of ammonia
Chloride precipitate soluble in dilute **(1)**
Bromide precipitate soluble in concentrated **(1)**
Iodide precipitate insoluble **(1)**

Do not allow halogen or sodium halide

6

[15]

52 C **[1]**

53 D **[1]**

54 C **[1]**

55 A **[1]**

56 A **[1]**

57 D [1]

58 D [1]

59 C [1]

60 B [1]