Q1. Which of these species is the best reducing agent?

A Cl_2 ⬭

B Cl^- ⬭

C I_2 ⬭

D I^- ⬭

(Total 1 mark)

Q2. 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)

Q3. 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)

Q4. 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)

Q5. 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)

Q6. 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)

Q7. 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)

Q8. 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)

Q9. 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)

Q10. 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)

Q11. 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)

Q12. 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)

Q13. 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)

Q14. 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)

Q15. 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)

Q16. 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)

Q17. 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)

Q18. 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)

Q19. Which one of the following statements is true?

A Bromine liberates iodine from aqueous sodium iodide.

B Chlorine liberates fluorine from aqueous sodium fluoride.

C Silver iodide is soluble in aqueous ammonia.

D Concentrated sulphuric acid liberates chlorine from solid sodium chloride.

(Total 1 mark)

Q1. 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.

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(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.

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(1)

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

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(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)

Q2. 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) .....

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(3)

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

Reagent .....

Observation with HCl(aq) .....

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Observation with HNO_3(aq) .....

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(3)

(c) Cyclohexane and cyclohexene

Reagent .....

Observation with cyclohexane .....

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Observation with cyclohexene .....

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(3)

(d) Butanal and butanone

Reagent .....

Observation with butanal .....

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Observation with butanone .....

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(3)
(Total 12 marks)

Q3. 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

.....

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Observation with 2−methylpropan−2−ol

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(3)

(b) Propane and propene

Reagent .....

Observation with propane

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Observation with propene

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(3)

(c) Aqueous silver nitrate and aqueous sodium nitrate

Reagent .....

Observation with aqueous silver nitrate

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Observation with aqueous sodium nitrate

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(3)

(d) Aqueous magnesium chloride and aqueous barium chloride

Reagent .....

Observation with aqueous magnesium chloride

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Observation with aqueous barium chloride

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(3)
(Total 12 marks)

Q4.(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)

Q5. 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)

Q6. 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 .....

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(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)

Q1.(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).

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(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.

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(1)

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

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(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.

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(1)

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

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(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.

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(1)

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

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(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.

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(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)

Q2.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) .....

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(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)

Q3. 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)

Q4. 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)

Q5. 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)

Q6.(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)

Q1. 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.

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(1)

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

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(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.

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(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.

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(1)

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

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(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*.

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(1)

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

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(1)

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

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(Extra space) .....

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(2)

(Total 15 marks)

Q2. (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)

Q3. 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 NHF_2

.....

(1)

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

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(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 .....

.....

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(2)

(Total 10 marks)

Q4. (a) Give the **formula** of a Group 2 metal hydroxide used in agriculture.

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(1)

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

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(1)

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

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

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(1)

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

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(1)

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

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

Formula of the solid reduction product .....

Formula of the oxidation product .....

(2)

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

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

(1)

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

(1)

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

(1)

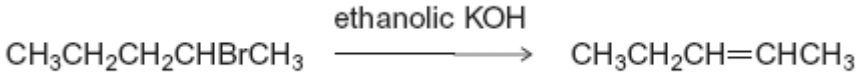
(iv) The bromoalkane that reacts with sodium cyanide to produce propanenitrile.

(1)
(Total 10 marks)

Q1. 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.

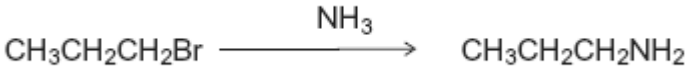
(1)

(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)

Q2.(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.

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(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.

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(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 .....

.....

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(3)
(Total 15 marks)

Q3. (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.

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(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.

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(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.

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(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)

Q4. 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.

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(1)
(Total 10 marks)

Q5. The presence of halide ions in solution can be detected by adding silver nitrate solution and dilute nitric acid.

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

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(1)

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

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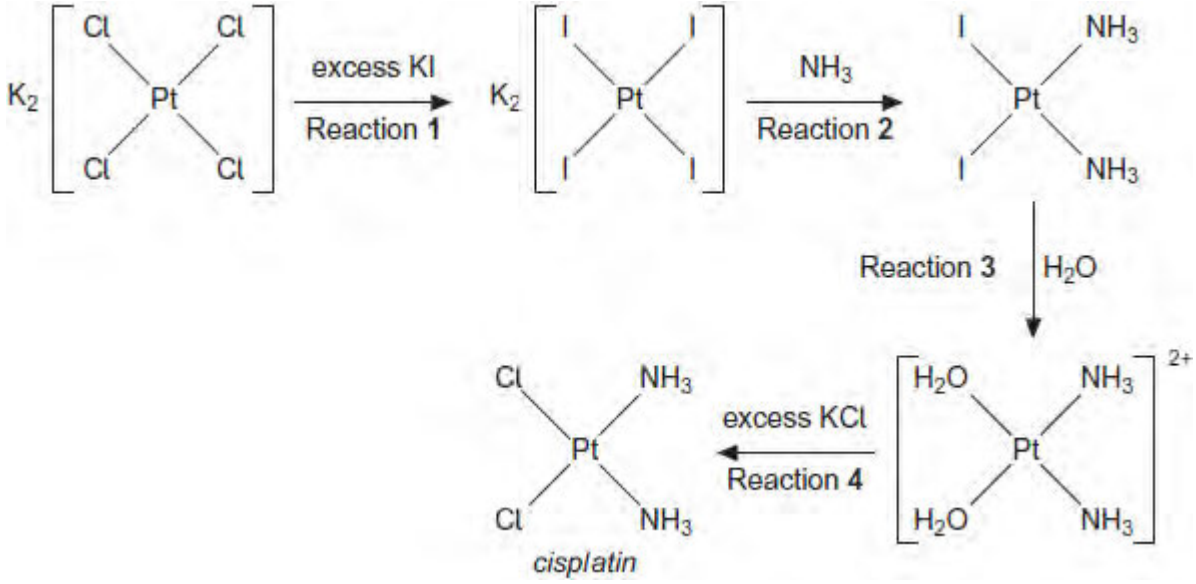
(2)
(Total 3 marks)

Q1. 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**.

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(2)

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

.....

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(1)

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

.....

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.....

(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.

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(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.

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(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)

Q2.A chemical company's records refer to the following acids

hydrochloric acid	nitric acid
hydrobromic acid	sulfuric acid
hydriodic 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 .....

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Observation .....

.....

(2)

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

.....

(1)
(Total 5 marks)

Q3. (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)

Q1. (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)

Q2. (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)

Q3.(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)

Q4. (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)

Q5.(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)

Q1. 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)

Q2. Which one of the following statements is true?

A Bromine liberates iodine from aqueous sodium iodide.

B Chlorine liberates fluorine from aqueous sodium fluoride.

C Silver iodide is soluble in aqueous ammonia.

D Concentrated sulphuric acid liberates chlorine from solid sodium chloride.

(Total 1 mark)

Q3. 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)

Q4. 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)

Q5. 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)

Q6. 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)

Q7. (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)

Q8. 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)

Q9. 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)

Q10. 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)

Q11. (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)

Q12. 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)

Q13. 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)

Q14. (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)

Q15. 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)

Q16. 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)

Q1. 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)

Q2. 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)

Q3. 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) .....

.....

(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)

Q4.(a) Chlorine displaces iodine from aqueous potassium iodide.

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

.....

(1)

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

.....

.....

(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)

Q5. 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.

$$\text{.....}KI + \text{.....}H_2SO_4 \longrightarrow \text{.....}KHSO_4 + \text{.....}I_2 + S + \text{.....}H_2O$$

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

(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.

.....

(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.

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(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.

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(1)

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

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.....

(1)

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

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(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)

Q1. 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.

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(2)

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

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

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

Half-equation 1

.....

Half-equation 2

.....

(2)

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

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(1)

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

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(2)

(Total 12 marks)

Q2. 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.

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(2)
(Total 13 marks)

Q3. (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.

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(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.

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(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.

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(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)

Q1. (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)

Q2. (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)

Q3. (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)

Q4. (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)

Q1. (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)

Q2. 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)

Q3. 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)