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Halogen 2

CHEMISTRY

Question Paper

AQA

AS & A LEVEL

Inorganic Chemistry

1 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)

2 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)

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(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)

3 (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)

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4 (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)

5 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)

6 (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.

.....

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(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)

7 (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)

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(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)

8 (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)

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(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 .....

.....

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(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)

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9 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)

10 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)

11 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)

12 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)

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13 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)

14 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)

15 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)

16 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)

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17 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)

18 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)

19 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)

20 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)

21 (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.

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(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)

22 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)

23 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)

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24 (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)

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25 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)

26 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)

27 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)

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(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)

28 (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)

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(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)

29 (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)

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(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)

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