AQA A-LEVEL CHEMISTRY · 7405

CHEMISTRY



EXAM QUESTION PACK

3.2.3 GROUP 7, THE HALOGENS

SCORE	PERCENTAGE
/281	%

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Q1.

Which statement is correct about the reaction between concentrated sulfuric acid and solid sodium bromide?

A Bromide ions are reduced. ⬭

B Hydrogen bromide and sulfur are formed. ⬭

C Sulfuric acid acts as an oxidising agent. ⬭

D Bromine and hydrogen sulfide are formed. ⬭

(Total 1 mark)

Q2.

Separate unlabelled solid samples of three anhydrous sodium compounds are provided for a student to identify.
These compounds are known to be sodium carbonate, sodium fluoride and sodium chloride but it is not known which sample is which.

Outline a logical sequence of test-tube reactions that the student could carry out to identify each of these compounds.
Include the observations the student would expect to make.
Give equations, including **state symbols**, for any reactions that would take place.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(Total 6 marks)

Q3.

An aqueous solution **Y** is known to contain one type of group 2 metal ion and one type of negative ion.

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Aqueous solutions of sulfuric acid and magnesium nitrate are added to separate samples of solution **Y**. The observations are shown in the table.

Solution added	**Observation with solution Y**
Sulfuric acid	A white precipitate forms
Magnesium nitrate	A white precipitate forms

(a) Suggest the identity of the group 2 metal ion present in solution **Y**.

Write an ionic equation, including state symbols, for the reaction that takes place when sulfuric acid is added to solution **Y**.

Group 2 metal ion _____

Ionic equation _____

(2)

(b) Suggest the identity of the negative ion present in solution **Y**.

Write an ionic equation, including state symbols, for the reaction that takes place when magnesium nitrate is added to solution **Y**.

Negative ion _____

Ionic equation _____

(2)

(Total 4 marks)

Q4.

Which is the best technique to remove the silver chloride that forms when aqueous solutions of silver nitrate and sodium chloride react?

A Refluxing ⬭

B Evaporation ⬭

C Filtration ⬭

D Distillation ⬭

(Total 1 mark)

Q5.

Which statement about astatine is correct?

A Astatine has a greater electronegativity than bromine ⬭

B Astatine is a better oxidising agent than bromine ⬭

C Astatine has a greater boiling point than bromine ⬭

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D Astatine has a greater first ionisation energy than bromine ⬭

(Total 1 mark)

Q6.

Which species is **not** produced by a redox reaction between solid sodium iodide and concentrated sulfuric acid?

A Na_2SO_4 ⬭

B H_2S ⬭

C S ⬭

D SO_2 ⬭

(Total 1 mark)

Q7.

This question is about silver iodide.

(a) Define the term enthalpy of lattice formation.

_____

_____

_____

(2)

(b) Some enthalpy change data are shown in the table.

	Enthalpy change / kJ mol^{-1}
$AgI(s) \longrightarrow Ag^+(aq) + I^-(aq)$	+112
$Ag^+(g) \longrightarrow Ag^+(aq)$	−464
$I^-(g) \longrightarrow I^-(aq)$	−293

Use the data in the table to calculate the enthalpy of lattice formation of silver iodide.

Enthalpy of lattice formation = _____ kJ mol^{-1}

(2)

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(c) A calculation of the enthalpy of lattice formation of silver iodide based on a perfect ionic model gives a smaller numerical value than the value calculated in part (b)

Explain this difference.

_____

_____

_____

_____

(2)

(d) Identify a reagent that could be used to indicate the presence of iodide ions in an aqueous solution and describe the observation made.

Reagent _____

Observation _____

_____

(2)

(Total 8 marks)

Q8.

Concentrated sulfuric acid reacts with alkenes, alcohols and sodium halides.

(a) Name the mechanism for the reaction of concentrated sulfuric acid with an alkene.

_____

(1)

(b) Outline the mechanism for the reaction of concentrated sulfuric acid with propene to show the formation of the major product.

(4)

(c) Draw the structure of the minor product of the reaction between concentrated sulfuric acid and propene.

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(1)

(d) Explain why the product shown in your answer to part (b) is the major product.

_____

_____

_____

_____

_____

_____

(2)

(e) Butan-2-ol reacts with concentrated sulfuric acid to form a mixture of three isomeric alkenes. Two of the alkenes are stereoisomers.

Draw the skeletal formula of each of the three isomeric alkenes formed by the reaction of butan-2-ol with concentrated sulfuric acid.

Give the full IUPAC name of each isomer.

Skeletal formula	Name

(3)

(f) A by-product of the reaction of butan-2-ol with concentrated sulfuric acid has the molecular formula C_4H_8O

Name this by-product, identify the role of the sulfuric acid in its formation and suggest the name of a method that could be used to separate the products of this reaction.

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By-product _____

_____

Role of sulfuric acid _____

_____

Name of separation method

_____

(3)

(g) Concentrated sulfuric acid reacts with solid sodium chloride.

Give the observation you would make in this reaction.

State the role of the sulfuric acid.

Observation with sodium chloride _____

_____

Role of sulfuric acid _____

_____

(2)

(h) Concentrated sulfuric acid reacts with solid sodium iodide, to produce several products.

Observations made during this reaction include the formation of a black solid, a yellow solid and a gas with the smell of bad eggs.

Identify the product responsible for each observation.

Black solid _____

Yellow solid _____

Gas _____

(3)

(Total 19 marks)

Q9.

A student was given a 50.0 g sample of solid silver chloride contaminated with solid silver carbonate.
The student suggested the following method to obtain the maximum amount of pure dry silver chloride from the sample:

1. Tip the solid into a boiling tube.

2. Add dilute nitric acid.

3. Allow the remaining solid to settle.

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4. Decant off the liquid.

5. Leave the sample to dry on a shelf.

Identify any faults or omissions in the method suggested by the student.
Suggest improvements to the method, using commonly available laboratory equipment.

The following chemicals are also available:
distilled water, dilute solutions of NaOH, NH_3, HCl, H_2SO_4

(Total 6 marks)

Q10.

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

(a) Bromine (Br_2), strontium chloride ($SrCl_2$) and iodine monochloride (ICl) all have similar M_r values.

Suggest, with reasons, the order of melting points for these three substances.

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_____

_____

_____

_____

_____

(6)

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

State a reason why chlorine is added to drinking water, and suggest a disadvantage of treating water in this way.

Equation

_____

Reason _____

_____

Disadvantage _____

_____

_____

(3)

(c) Bromine reacts with phosphorus to form phosphorus tribromide.

Write an equation for this reaction and draw the shape of the phosphorus tribromide molecule formed.

Suggest the bond angle in phosphorus tribromide.

Equation

_____

Shape

Bond angle _____

(3)

(d) Phosphorus pentabromide in the solid state consists of PBr_4^+ and Br^- ions.

Draw the shape of the PBr_4^+ ion and suggest its bond angle.

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Shape

Bond angle _____

(2)

(Total 14 marks)

Q11.

Which equation represents a reaction that does take place?

A $Cl_2 + 2NaI \longrightarrow 2NaCl + I_2$ ○

B $Br_2 + 2NaCl \longrightarrow 2NaBr + Cl_2$ ○

C $NaCl + H_2O \longrightarrow HCl + NaOH$ ○

D $2HCl + H_2SO_4 \longrightarrow Cl_2 + SO_2 + 2H_2O$ ○

(Total 1 mark)

Q12.

Which species is the best oxidising agent?

A Cl_2 ○

B Cl^- ○

C Br_2 ○

D Br^- ○

(Total 1 mark)

Q13.

The following tests were carried out to identify an unknown green salt **Y**.

An aqueous solution of **Y** gave a cream precipitate of compound **A** when reacted with silver nitrate solution.

Compound **A** gave a colourless solution when reacted with concentrated ammonia solution.

Another aqueous solution of **Y** gave a green precipitate **B** when reacted with sodium carbonate solution.

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The green precipitate **B** was filtered and dried and then reacted with sulfuric acid to give a pale green solution containing compound **C** and a colourless gas **D**.

(a) Identify by name or formula the compounds **A**, **B**, **C**, **D** and **Y**.

Identity of **A** _____

Identity of **B** _____

Identity of **C** _____

Identity of **D** _____

Identity of **Y** _____

(5)

(b) Write the simplest ionic equation for the reaction of silver nitrate solution with the anion that is present in compound **Y**.

_____

(1)

(c) Write the simplest ionic equation for the reaction that occurs between the green precipitate **B** and sulfuric acid.

_____

(1)

(Total 7 marks)

Q14.

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.

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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.

(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.

(2)

(Total 11 marks)

Q15.

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)

Q16.

A Grignard reagent is a compound in which magnesium is bonded to an alkyl group (R)

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and a halogen (X). It can be represented by the formula RMgX.

A Grignard reagent is formed by the reaction of magnesium metal with a haloalkane using dry ethoxyethane as a solvent. Ethoxyethane has a boiling point of 35 ºC, forms a dense vapour and is highly flammable.

(a) Give **one** reason why a hot water bath is used rather than direct heating with a Bunsen burner when preparing the Grignard reagent.

_____

(1)

(b) Grignard reagents react with water.

Suggest **one** reason why the ethoxyethane protects the Grignard reagent from reacting with water vapour in the air.

_____

(1)

(c) A Grignard reagent can be used to introduce an extra carbon atom into an organic molecule.
For example, propanone (CH_3COCH_3) reacts with CH_3MgBr in a two-stage process to form 2-methylpropan-2-ol, $(CH_3)_3COH$. The isomer 2-methylpropan-1-ol is not formed in this process.

Suggest a suitable reagent and the associated observations that could be used to distinguish between 2-methylpropan-2-ol and its isomer 2-methylpropan-1-ol.

Reagent _____

Observation with 2-methylpropan-2-ol _____

_____

Observation with 2-methylpropan-1-ol _____

_____

(3)

(d) At the end of the preparation of the alcohol, the bromine from the Grignard reagent remains as the bromide ion.
Suggest reagents and observations to confirm that this halide ion is Br^- and not I^-

_____

_____

_____

_____

_____

_____

_____

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_____

_____

(4)

(Total 9 marks)

Q17.

Silver cyanide can be precipitated from sodium cyanide solution by adding an excess of silver nitrate solution.

Describe how you would obtain a pure dry sample of silver cyanide from this mixture.

_____

_____

_____

_____

_____

(Total 3 marks)

Q18.

A student oxidised a solution of hydrochloric acid with a few drops of sodium chlorate(I) solution. The reaction mixture effervesced and turned pale green. The gas formed bleached universal indicator paper.

(a) Write a half-equation for the oxidation of chloride ions.

_____

(1)

(b) Write a half-equation for the reduction of chlorate(I) ions to chlorine in acidic conditions.

_____

(1)

(c) Write an overall equation for the redox reaction of chlorate(I) ions with hydrochloric acid.

_____

(1)

(d) A solution of sodium chlorate(I) was added to a colourless solution of potassium iodide.
Suggest what is observed.

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Explain the reaction that leads to this observation.

_____

_____

_____

_____

_____

(3)

(Total 6 marks)

Q19.

The halogens are the elements in Group 7.

(a) The electronegativities of the halogens are shown in the table.

Halogen	**Fluorine**	**Chlorine**	**Bromine**	**Iodine**
Electronegativity	4.0	3.0	2.8	2.5

Explain the trend in electronegativities shown by the halogens.

_____

_____

_____

_____

(2)

(b) The halogens can all behave as oxidising agents in reactions.

(i) Explain, in terms of electron transfer, the meaning of the term oxidising agent.

_____

_____

(1)

(ii) An equation for the reaction that takes place when chlorine gas is bubbled through aqueous potassium bromide is shown.

$$Cl_2(g) + 2KBr(aq) \longrightarrow Br_2(aq) + 2KCl(aq)$$

Explain, with reference to the oxidation states, why this is a redox reaction.

_____

_____

_____

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(1)

(c) Solid sodium halides react with concentrated sulfuric acid.

(i) A sample of solid sodium iodide is reacted with concentrated sulfuric acid. A black solid forms and hydrogen sulfide gas is produced.

Write a half-equation for the reaction of sulfuric acid to form hydrogen sulfide.

_____

(1)

(ii) Write a half-equation for the formation of the black solid.

_____

(1)

(iii) Use your answers to parts (c) (i) and (c) (ii) to write an overall equation for the reaction of sodium iodide with concentrated sulfuric acid.

_____

(1)

(iv) Give the role of sulfuric acid in its reaction with sodium iodide.

Tick (✓) **one** box.

Acid	☐
Oxidising agent	☐
Reducing agent	☐
Electrophile	☐

(1)

(v) Write an equation for the reaction of concentrated sulfuric acid with solid sodium fluoride.

_____

(1)

(vi) Suggest **one** reason why the reaction of sodium fluoride with concentrated sulfuric acid is different from the reaction with sodium iodide.

_____

(1)

(d) Chlorine reacts with water to form an equilibrium mixture containing hydrochloric acid and chloric(I) acid.

(i) Write an equation for the formation of this equilibrium mixture.

_____

(1)

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(ii) Household bleach contains sodium chlorate(I) and sodium chloride.
State and explain, with reference to your equation in part **(d)(i)**, why it is dangerous to acidify an aqueous mixture of sodium chlorate(I) and sodium chloride.

_____

_____

_____

(2)

(Total 13 marks)

Q20.

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

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

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

Reagent _____

Observation with butan−2−ol

_____

_____

Observation with 2−methylpropan−2−ol

_____

_____

(3)

(b) Propane and propene

Reagent _____

Observation with propane

_____

_____

Observation with propene

_____

_____

(3)

(c) Aqueous silver nitrate and aqueous sodium nitrate

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Reagent _____

Observation with aqueous silver nitrate

_____

_____

Observation with aqueous sodium nitrate

_____

_____

(3)

(d) Aqueous magnesium chloride and aqueous barium chloride

Reagent _____

Observation with aqueous magnesium chloride

_____

_____

Observation with aqueous barium chloride

_____

_____

(3)

(Total 12 marks)

Q21.

Chlorine is an important industrial chemical.

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

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

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

_____

(1)

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

_____

(1)

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

_____

(1)

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

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

_____

(1)

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

_____

_____

(1)

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

_____

_____

(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.

_____

_____

_____

_____

_____

_____

_____

(2)

(Total 10 marks)

Q22.

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

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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.

_____

_____

_____

_____

_____

(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.

_____

_____

(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.

_____

_____

_____

_____

_____

(3)

(Total 7 marks)

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Q23.

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

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

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

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

_____

(1)

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

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

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

_____

_____

(1)

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

_____

_____

(1)

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

_____

_____

_____

_____

(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.

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

_____

_____

(1)

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

_____

_____

(1)

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

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

_____

(1)

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

_____

_____

(1)

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

Write an equation for the thermal decomposition of calcium ethanoate.

_____

(1)

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

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

_____

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_____

_____

_____

_____

_____

_____

(3)

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

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

_____

_____

_____

_____

_____

_____

(2)

(Total 15 marks)

Q24.

(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.

_____

(1)

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

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_____

_____

_____

_____

_____

_____

(2)

(Total 5 marks)

Q25.

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

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

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

Reagent _____

Observation with AgBr(s) _____

_____

Observation with AgI(s) _____

_____

(3)

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

Reagent _____

Observation with HCl(aq) _____

_____

Observation with HNO_3(aq) _____

_____

(3)

(c) Cyclohexane and cyclohexene

Reagent _____

Observation with cyclohexane _____

_____

Observation with cyclohexene _____

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_____

(3)

(d) Butanal and butanone

Reagent _____

Observation with butanal _____

_____

Observation with butanone _____

_____

(3)

(Total 12 marks)

Q26.

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)

Q27.

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

_____

_____

_____

_____

_____

_____

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_____

_____

_____

_____

(Total 5 marks)

Q28.

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.

_____

_____

_____

_____

(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.

_____

_____

_____

_____

_____

_____

(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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_____

_____

(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.

_____

_____

_____

_____

_____

_____

(3)

(Total 10 marks)

Q29.

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**.

_____

_____

_____

_____

_____

(3)

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(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**.

_____

_____

_____

_____

_____

(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**.

_____

_____

(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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_____

_____

_____

_____

(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.

_____

_____

_____

_____

_____

_____

(3)

(Total 15 marks)

Q30.

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.

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The final stage involves the reaction between $NaIO_3$ and NaI in acidic solution. Half-equations for the redox processes are given below.

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

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

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

Overall ionic equation

The oxidising agent _____

(2)

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

(i) Identify the black solid.

_____

(1)

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

_____

(1)

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

_____

(1)

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

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(ii) 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 precipitate.

_____

_____

(1)

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

_____

_____

(1)

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

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

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

_____

_____

(1)

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

_____

(1)

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

_____

_____

_____

_____

(2)

(Total 15 marks)

Q31.

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

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

_____

_____

_____

(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

_____

(1)

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

$$NHF_2 + BF_3 \longrightarrow F_2HNBF_3$$

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

Explain how this bond is formed.

Name of type of bond _____

How bond is formed _____

_____

_____

(2)

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(Total 10 marks)

Q32.

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

_____

(1)

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

_____

(1)

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

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

_____

(1)

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

_____

(1)

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

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

Formula of the solid reduction product _____

Formula of the oxidation product _____

(2)

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

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

(1)

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

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(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)

Q33.

(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.

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Identify the other sodium halide that must be present in this mixture of two sodium halides.

_____

_____

_____

_____

(3)

(ii) Give **one** reason why the silver nitrate solution was acidified before it was used in this test.

_____

_____

_____

(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.

_____

_____

_____

_____

(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.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(5)

(Total 15 marks)

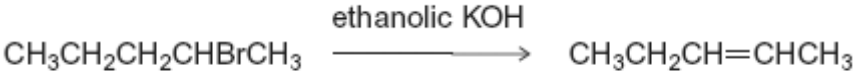
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Q34.

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.

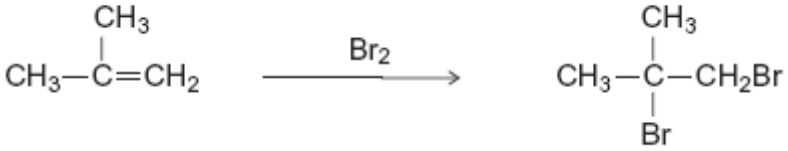


(4)

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

(1)

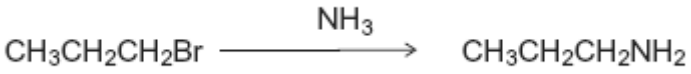
(b) Name and outline a mechanism for the following conversion.



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(5)

(c) Name and outline a mechanism for the following conversion.



(5)
(Total 15 marks)

Q35.

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

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Solution **A**	no visible change	white precipitate
Solution **B**	no visible change	no visible change
Solution **C**	effervescence (bubbles of gas)	no visible change

(a) Use the observations in the table to deduce which of the solutions, **A, B** or **C** is

hydrochloric acid _____

barium chloride _____

(2)

(b) Explain why a precipitate was formed when copper(II) sulfate solution was added to solution **A**.
Write an equation for the reaction that occurred.

Explanation _____

_____

Equation _____

(2)

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

_____

(1)

(d) Identify the two reagents that could be used in a test to confirm that the solutions contained chloride ions, **not** bromide ions. State what would be observed on addition of each reagent.

Reagent 1 _____

Observation 1 _____

_____

Reagent 2 _____

Observation 2 _____

_____

(4)

(e) Copper(II) sulfate is toxic. Suggest **one** safety precaution you would take to minimise this hazard when wiping up a spillage of copper(II) sulfate solution.

_____

(1)

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(Total 10 marks)

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