

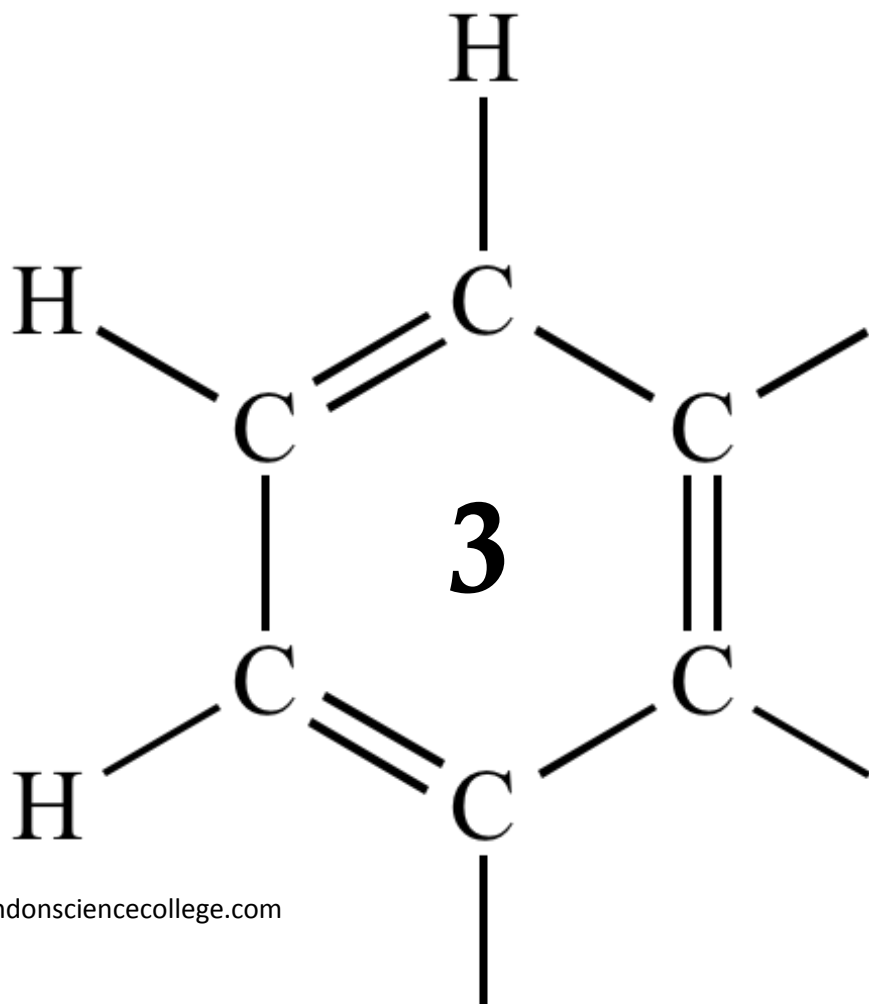
OCR AS CHEMISTRY

MODULE 3

GROUP 2

GROUP 7

IONISATION ENERGIES



1

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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(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)

(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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(3)
(Total 10 marks)

2

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.



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.



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)

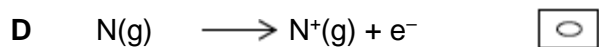
3

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 Na₂SO₄
- C NaBr
- D NaF

(Total 1 mark)

4 Which change requires the largest amount of energy?



(Total 1 mark)

5 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

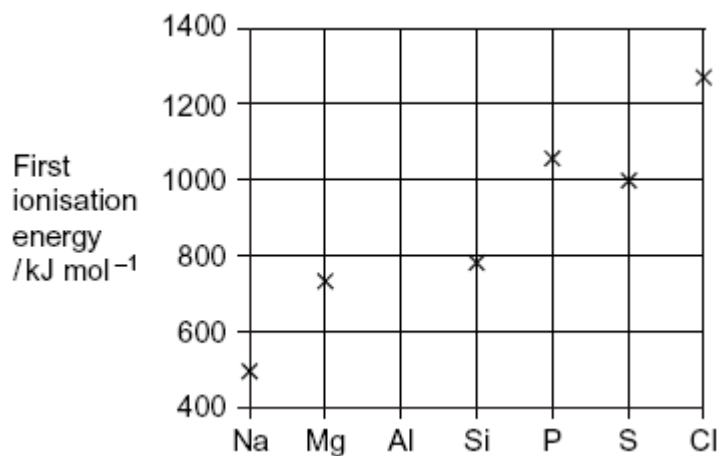
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(3)

(Total 12 marks)

6

The following diagram shows the first ionisation energies of some Period 3 elements.



(a) Draw a cross on the diagram to show the first ionisation energy of aluminium.

(1)

(b) Write an equation to show the process that occurs when the first ionisation energy of aluminium is measured.

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(2)

(c) State which of the first, second or third ionisations of aluminium would produce an ion with the electron configuration $1s^2 2s^2 2p^6 3s^1$

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(1)

(d) Explain why the value of the first ionisation energy of sulfur is less than the value of the first ionisation energy of phosphorus.

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(2)

(e) Identify the element in Period 2 that has the highest first ionisation energy and give its electron configuration.

Element

Electron configuration

(2)

(f) State the trend in first ionisation energies in Group 2 from beryllium to barium. Explain your answer in terms of a suitable model of atomic structure.

Trend

Explanation

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(3)
(Total 11 marks)

7

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

	BaCl₂ + HCl	AgNO₃ + HNO₃	NaOH	Na₂CO₃	HCl (conc)
Q	no change observed	pale cream precipitate	white precipitate	white precipitate	no change observed
R	no change observed	white precipitate	white precipitate, dissolves in excess of NaOH	white precipitate, bubbles of a gas	no change observed
S	white precipitate	no change observed	brown precipitate	brown precipitate, bubbles of a gas	yellow solution

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

Identity of **Q**

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Identity of **R**

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Identity of **S**

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(6)

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

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(4)
(Total 10 marks)

8

Iodine reacts with concentrated nitric acid to produce nitrogen dioxide (NO₂).

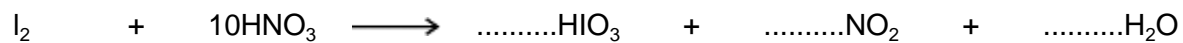
(a) (i) Give the oxidation state of iodine in each of the following.

I₂

HIO₃.....

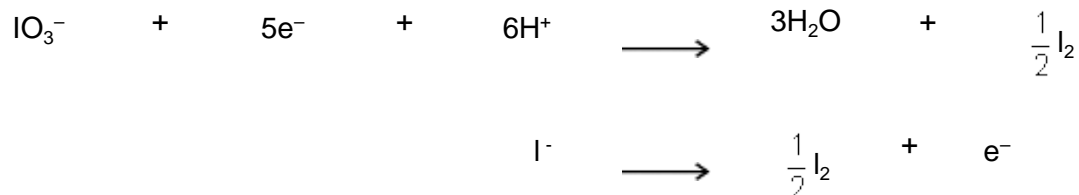
(2)

(ii) Complete the balancing of the following equation.



(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.



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.

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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.



(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)

9

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).....
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(2)

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

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

Shape of NHF_2

Shape of BF_3

Name of shape of NHF_2

Name of shape of BF_3

(4)

(ii) Suggest a value for the F—N—F bond angle in NH_2F

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(1)

(c) State the strongest type of intermolecular force in a sample of NH_2F

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(1)

(d) A molecule of NH_2F reacts with a molecule of BF_3 as shown in the following equation.



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)

10

(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)

11

(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
^1H	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)

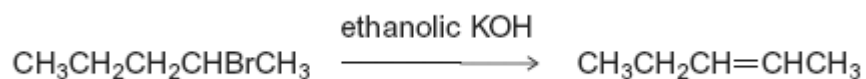
12

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.

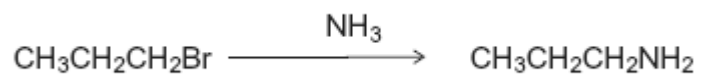
(1)

(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)