Wellingborough School
Founded 1595

SAMPLE PAPER

CHEMISTRY

SCHOLARSHIP EXAMINATION 16+

Candidate Number:

Time:

- 1 ½ hours

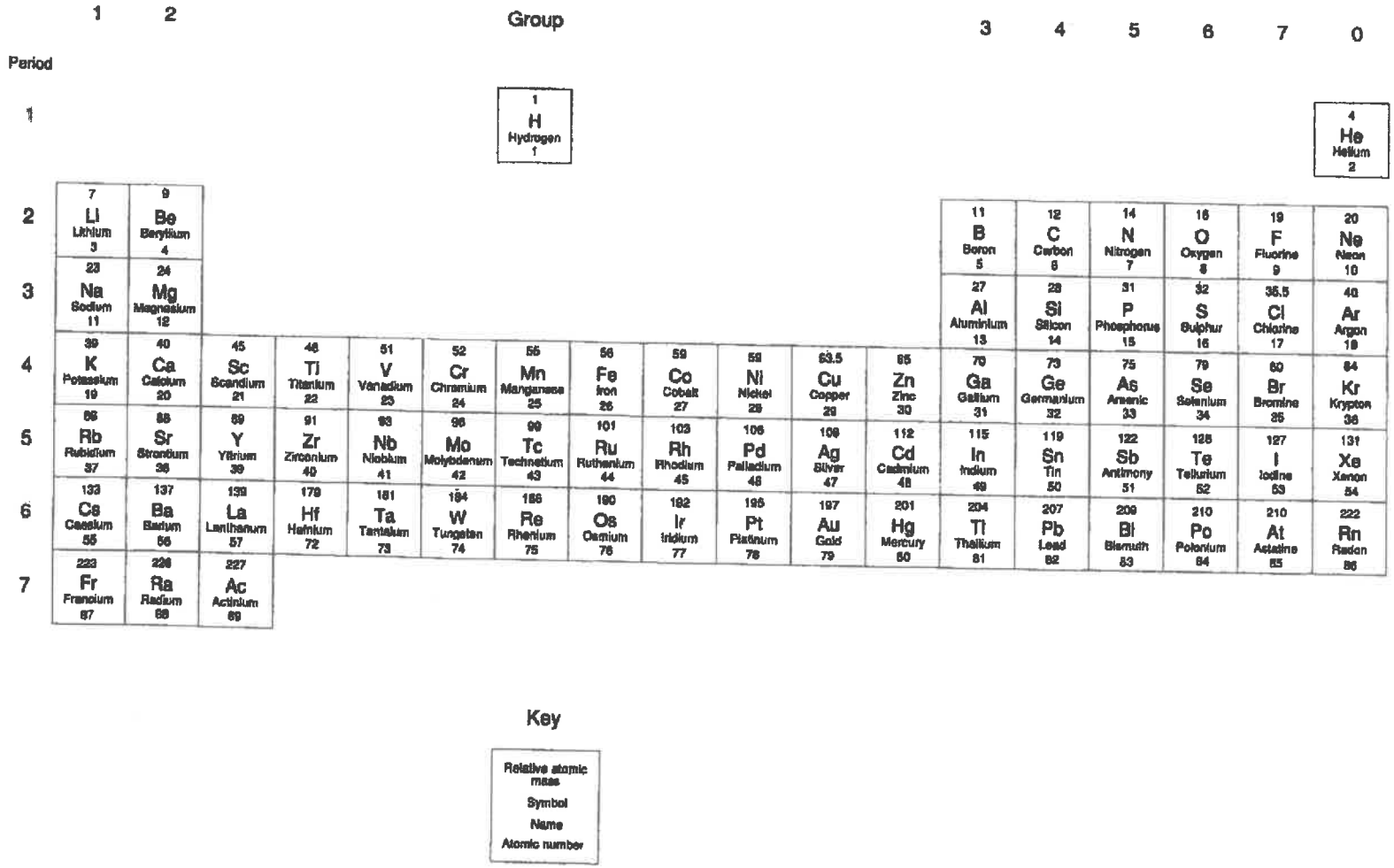
Instructions to Candidates:

- Answer all questions in the spaces provided

Information for Candidates:

- Writing and presentation are important. Poor presentation or failure to pay due attention to spelling and punctuation may lose marks.

THE PERIODIC TABLE



Key

Q1. A student was investigating the reaction of lithium and water.

She added a few drops of universal indicator to water in a trough and added a piece of lithium.

The word equation for the reaction is:

lithium + water ⟶ lithium hydroxide + hydrogen

(a) (i) The lithium floated on the water.

State **two** other observations that the student would **see** during the reaction.

1 .....

2 .....

(2)

(ii) Balance the symbol equation for the reaction of lithium and water.

2 Li(s) + ... $H_2O(l)$ ⟶ ..... LiOH(aq) + $H_2(g)$

(2)

(iii) Describe a simple test and the result that would show the gas was hydrogen.

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(1)

(iv) All Group 1 metals have similar reactions with water.

State why, in terms of electronic structure.

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(1)

(b) Lithium and other Group 1 metals have different properties from the transition metals.

Tick (✓) **two** properties that are properties of Group 1 metals.

They react with oxygen. ☐

They form coloured compounds. ☐

They are strong and hard. ☐

They have low melting points. ☐

(2)

(c) The electronic structure of a potassium atom is 2, 8, 8, 1

(i) Draw a diagram to show the electronic structure of a potassium ion.

Show the charge on the potassium ion.

(2)

(ii) Potassium is more reactive than sodium.

Explain why, in terms of electronic structure.

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(3)
(Total 13 marks)

Q2. (a) Which sub-atomic particles are present in the nucleus of an atom?

..... and .....

(2)

(b) There are two isotopes of the element chlorine:

$^{35}_{17}Cl$ $^{37}_{17}Cl$

Describe, in terms of sub-atomic particles, **one** similarity and **one** difference between atoms of the two isotopes of chlorine.

Similarity .....

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Difference .....

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(2)

(c) Chlorine reacts with hydrogen to produce hydrogen chloride.

(i) The table shows the values of some bond dissociation energies.

Bond	H—H	Cl—Cl	H—Cl
Dissociation energy in kJ per mole	436	242	431

Use the values in the table to calculate the enthalpy change (ΔH) for the reaction.

$$H_2(g) + Cl_2(g) \longrightarrow 2\,HCl(g)$$

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Enthalpy change (ΔH) = ... kJ per mole

(3)

(ii) Hydrogen also reacts with fluorine.

$H_2(g) + F_2(g) \longrightarrow 2\,HF(g) \qquad \Delta H = -538$ kJ per mole

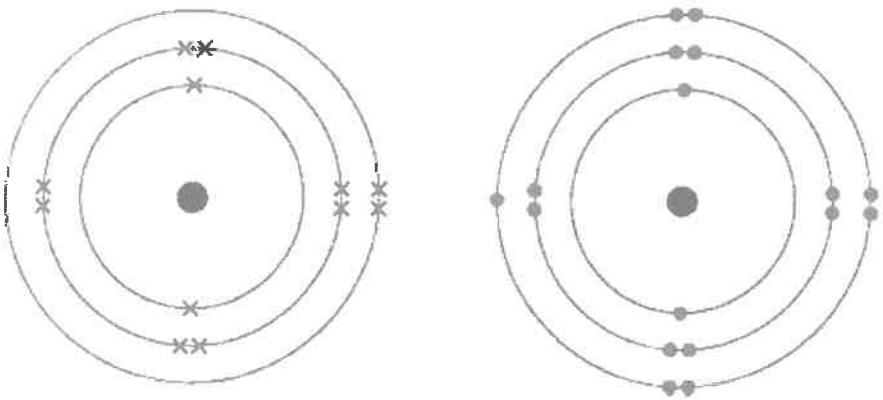
Draw an energy level diagram for this reaction.

Include on your diagram labels to show:

- the reactants and the products
- the overall enthalpy change (ΔH)
- the activation energy.

(3)
(Total 10 marks)

Q3. (a) The diagram shows an atom of magnesium and an atom of chlorine.



Magnesium **Chlorine**

Describe, in terms of electrons, how magnesium atoms and chlorine atoms change into ions to produce magnesium chloride ($MgCl_2$).

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(4)

(b) Calculate the relative formula mass (M_r) of magnesium chloride ($MgCl_2$).

Relative atomic masses (A_r): magnesium = 24; chlorine = 35.5

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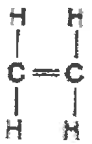
Relative formula mass (M_r) = ...

(2)
(Total 6 marks)

Q4. A molecule of ethene (C_2H_4) is represented as:



(a) A sample of ethene is shaken with bromine water.

Complete the sentence.

The bromine water turns from orange to .....

(1)

(b) Most ethene is produced by the process of cracking.

(i) Complete the sentence.

Cracking is a type of thermal .....

(1)

(ii) Decane ($C_{10}H_{22}$) can be cracked to produce ethene (C_2H_4) and **one** other product.

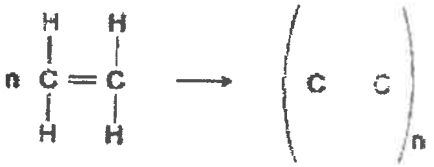
Complete the equation to show the formula of the other product.

$C_{10}H_{22} \longrightarrow C_2H_4 +$ .....

(1)

(c) Many molecules of ethene join together to produce poly(ethene).

(i) Complete the structure of the polymer in the equation.



(2)

(ii) Some carrier bags are made from poly(ethene). Some carrier bags are made from cornstarch.

Suggest **two** benefits of using cornstarch instead of poly(ethene) to make carrier bags.

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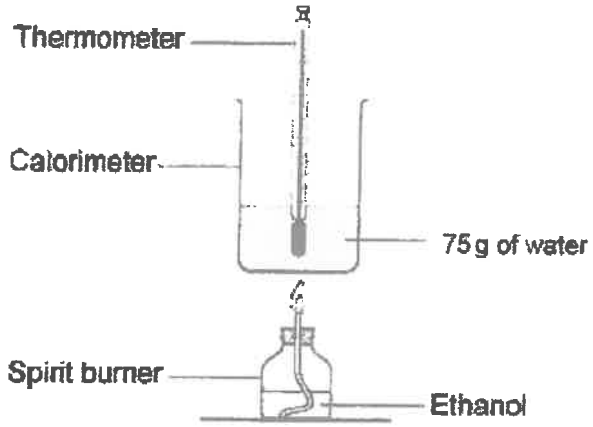
(2)
(Total 7 marks)

Q5. Ethanol is a liquid fuel which can be used as an alternative to gasoline.

(a) All fuels release energy when they are burned. A student did an experiment to find out how much heat energy is produced when ethanol is burned.

She used the apparatus shown in the diagram.



The student's results are shown in the table.

Experiment number	Mass of ethanol used in g	Temperature change of water in °C	Energy used to heat water in kJ	Energy given out by 1.00 g of fuel in kJ
1	0.78	52	16.4	21.0
2	0.64	43	13.5	21.1
3	0.68	45	14.2	.....

(i) Complete the table to show the energy given out by 1 g of ethanol in experiment number 3.

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(1)

(ii) What measurements must the student have made during the experiment to be able to record the temperature change of the water and the mass of ethanol used?

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(2)

(iii) The student used the same burner and calorimeter in each experiment.

Give **two** other variables that the student should have controlled.

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(2)

(iv) Explain why the student repeated the experiment three times?

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(2)

(v) The student looked in a data book and found that 1.00 g of ethanol should have given out 29.8 kJ.

Suggest **two** reasons why the results she obtained are much less than this.

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(2)

(b) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

Ethanol for fuel can be made by fermentation of plant materials. Ethanol that is produced by this process is a biofuel.

Evaluate the advantages and disadvantages of using ethanol made by fermentation as an alternative to gasoline. Remember to give a conclusion in your answer.

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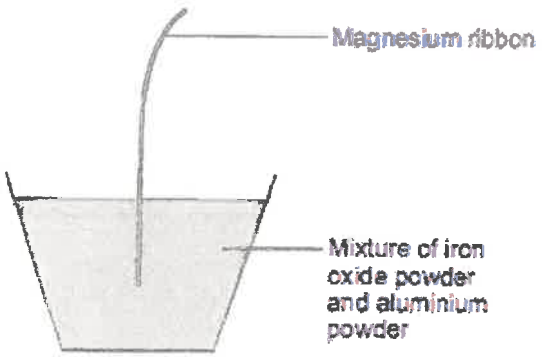
(6)
(Total 15 marks)

Q6. The diagram shows one way of producing iron.



Iron oxide reacts with aluminium to produce iron.

The symbol equation for the reaction is:

$Fe_2O_3 + 2\,Al \longrightarrow 2\,Fe + Al_2O_3$

(a) (i) Complete the word equation for this reaction.

iron oxide + aluminium ⟶ iron + ...

(1)

(ii) The magnesium ribbon is lit to start the reaction.

Why does the burning magnesium ribbon start the reaction?

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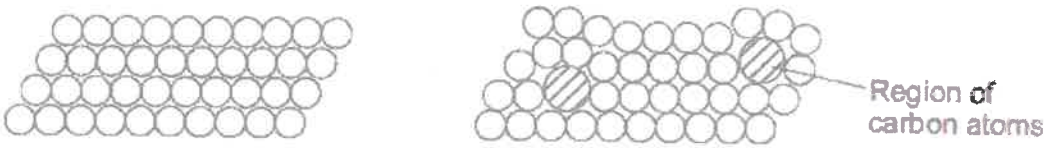
(1)

(b) In industry, iron is produced in the blast furnace when iron oxide is heated with carbon.

The iron from the blast furnace is called cast iron.

Cast iron contains carbon.

The diagrams show the structure of pure iron and cast iron.



Pure iron

Cast iron

Use the diagrams to help you answer the questions.

(i) Draw a ring around the correct answer to complete the sentence.

Pure iron is an element because pure iron

contains only one sort of atom.
is magnetic.
is a metal.

(1)

(ii) Suggest why cast iron is harder than pure iron.

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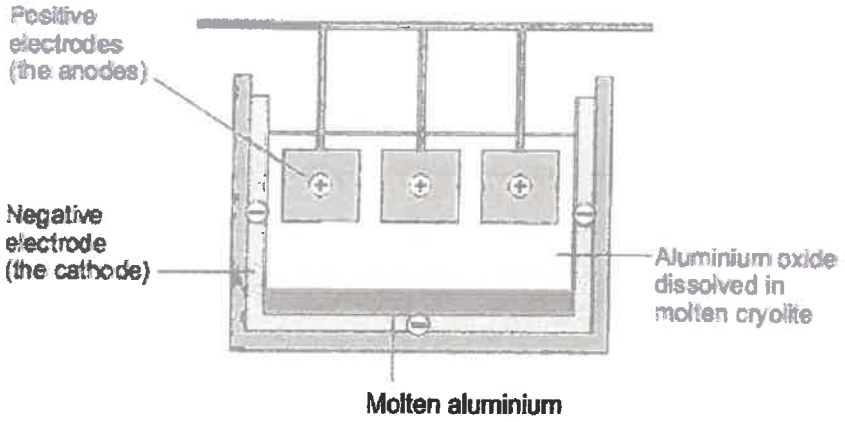
(2)

(c) Aluminium is extracted by electrolysis using the ionic compound aluminium oxide.



(i) Aluminium **cannot** be extracted by heating aluminium oxide with carbon.

Suggest why.

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(1)

(ii) Why is aluminium oxide dissolved in molten cryolite?

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(1)

(iii) Aluminium metal is produced at the negative electrode (cathode).

Complete the half equation for the process.

Al^{3+} + ... e^- ⟶ Al

(1)

(iv) Use the half equation to state why Al^{3+} ions are reduced.

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(1)

(v) Explain why the positive electrodes (anodes) burn away.

Use your knowledge of the products of electrolysis to help you.

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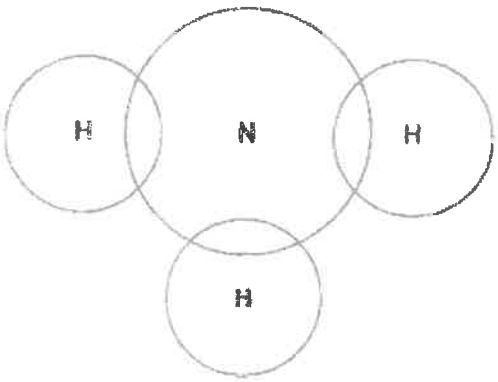
(4)
(Total 13 marks)

Q7. (a) Complete the dot and cross diagram to show the electrons in the outer energy levels of ammonia (NH_3).

You may use the periodic table to help you.



(2)

(b) Ammonia can be used to make ammonium nitrate (NH_4NO_3).

(i) Draw a ring around the correct answer to complete the sentence.

Ammonium nitrate can be made by reacting ammonia with [ethanoic / hydrochloric / nitric] acid.

(1)

(ii) State **one** use of ammonium nitrate.

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(1)

(iii) Calculate the relative formula mass (M_r) of ammonium nitrate (NH_4NO_3).

Relative atomic masses: H = 1; N = 14; O = 16.

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Relative formula mass (M_r) = ...

(2)

(iv) Calculate the percentage by mass of nitrogen in ammonium nitrate.

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Percentage by mass of nitrogen = ... %

(2)

(c) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

Ammonia is manufactured from nitrogen and hydrogen by the Haber process:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2\,NH_3(g)$$

The forward reaction is exothermic.

The conditions used in the Haber process are:

- 200 atmospheres pressure
- 450 °C
- iron catalyst.

Use the equation and your knowledge of reversible reactions to explain why these conditions are used in the Haber process.

To get full marks you must consider **both** yield **and** rate of reaction in your answer.

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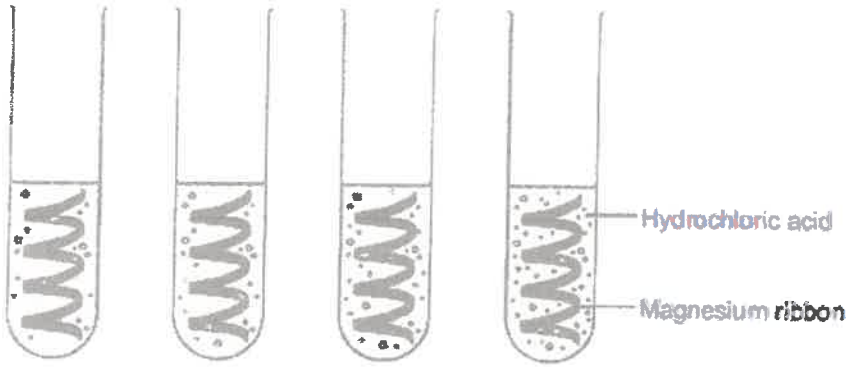
(6)
(Total 14 marks)

Q8. A student investigated the rate of reaction of magnesium and hydrochloric acid.

$$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$$

The student studied the effect of changing the concentration of the hydrochloric acid.

She measured the time for the magnesium to stop reacting.



Concentration of hydrochloric acid in moles per dm^3	0.5	1.0	1.5	2.0

(a) The student changed the concentration of the hydrochloric acid.

Give **two** variables that the student should control.

1 .....

2 .....

(2)

(b) (i) The rate of reaction increased as the concentration of hydrochloric acid increased.

Explain why.

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(2)

(ii) Explain why increasing the temperature would increase the rate of reaction.

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(3)

(c) (i) The student had a solution of sodium hydroxide with a concentration of 0.100 moles per dm^3.

She wanted to check the concentration of a solution of hydrochloric acid.

She used a pipette to transfer 5.00 cm^3 of the hydrochloric acid into a conical flask.

She filled a burette with the 0.100 moles per dm^3 sodium hydroxide solution.

Describe how she should use titration to obtain accurate results.

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(4)

(ii) Sodium hydroxide neutralises hydrochloric acid as shown in the equation:

$$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$$

The student found that 27.20 cm^3 of 0.100 moles per dm^3 sodium hydroxide neutralised 5.00 cm^3 of hydrochloric acid.

Calculate the concentration of the hydrochloric acid in moles per dm^3.

Give your answer to three significant figures.

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Concentration of hydrochloric acid = ... moles per dm^3

(3)

(Total 14 marks)