

Surname	Centre Number	Candidate Number
Other Names		2



**GCE A level**

1095/01

**CHEMISTRY – CH5**

### ADDITIONAL MATERIALS

In addition to this examination paper, you will need:

- a calculator;
- an 8 page answer book;
- a copy of the **Periodic Table** supplied by WJEC.  
Refer to it for any **relative atomic masses** you require.

### INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

**Section A** Answer **all** questions in the spaces provided.

**Section B** Answer **both** questions in **Section B** in a separate answer book which should then be placed inside this question-and-answer book.

Candidates are advised to allocate their time appropriately between **Section A (40 marks)** and **Section B (40 marks)**.

### INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

You are reminded that marking will take into account the Quality of Written Communication in all written answers.

FOR EXAMINER'S USE ONLY		
Section	Question	Mark
A	1	
	2	
	3	
B	4	
	5	
TOTAL MARK		

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010001

## SECTION A

*Answer all questions in the spaces provided.*

1. Halogens and their compounds take part in a wide variety of reactions.

- (a) Give the chemical name of a chlorine-containing compound of commercial or industrial importance. State the use made of this compound. [1]

.....

.....

- (b) Hydrogen reacts with iodine in a reversible reaction.



An equilibrium was established at 300 K, in a vessel of volume 1 dm<sup>3</sup>, and it was found that 0.311 mol of hydrogen, 0.311 mol of iodine and 0.011 mol of hydrogen iodide were present.

- (i) Write the expression for the equilibrium constant in terms of concentration,  $K_c$ . [1]

- (ii) Calculate the value of  $K_c$  at 300 K. [1]

$K_c =$  .....

- (iii) What are the units of  $K_c$ , if any? [1]

.....

- (iv) Equilibria of H<sub>2</sub>, I<sub>2</sub> and HI were set up at 500 K and 1000 K and it was found that the numerical values of  $K_c$  were  $6.25 \times 10^{-3}$  and  $18.5 \times 10^{-3}$  respectively.

Use these data to deduce the sign of  $\Delta H$  for the forward reaction. Explain your reasoning. [3]

.....

.....

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.....

- (c) When concentrated hydrochloric acid is added to a pink aqueous solution of cobalt(II) chloride, the colour changes to blue.

Cobalt takes part in an equilibrium reaction.



- (i) What is the oxidation state of cobalt in  $[\text{CoCl}_4]^{2-}$ ? [1]  
.....
- (ii) What type of bonding is present in  $[\text{CoCl}_4]^{2-}$ ? [1]  
.....
- (iii) Use the equation to identify the ions responsible for the pink and blue colours described above. Explain why the colour change occurs when concentrated hydrochloric acid is added to the pink solution. [3]  
.....  
.....  
.....  
.....
- (iv) Draw diagrams to clearly show the shape of the  $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$  ion and the  $[\text{CoCl}_4]^{2-}$  ion. [2]

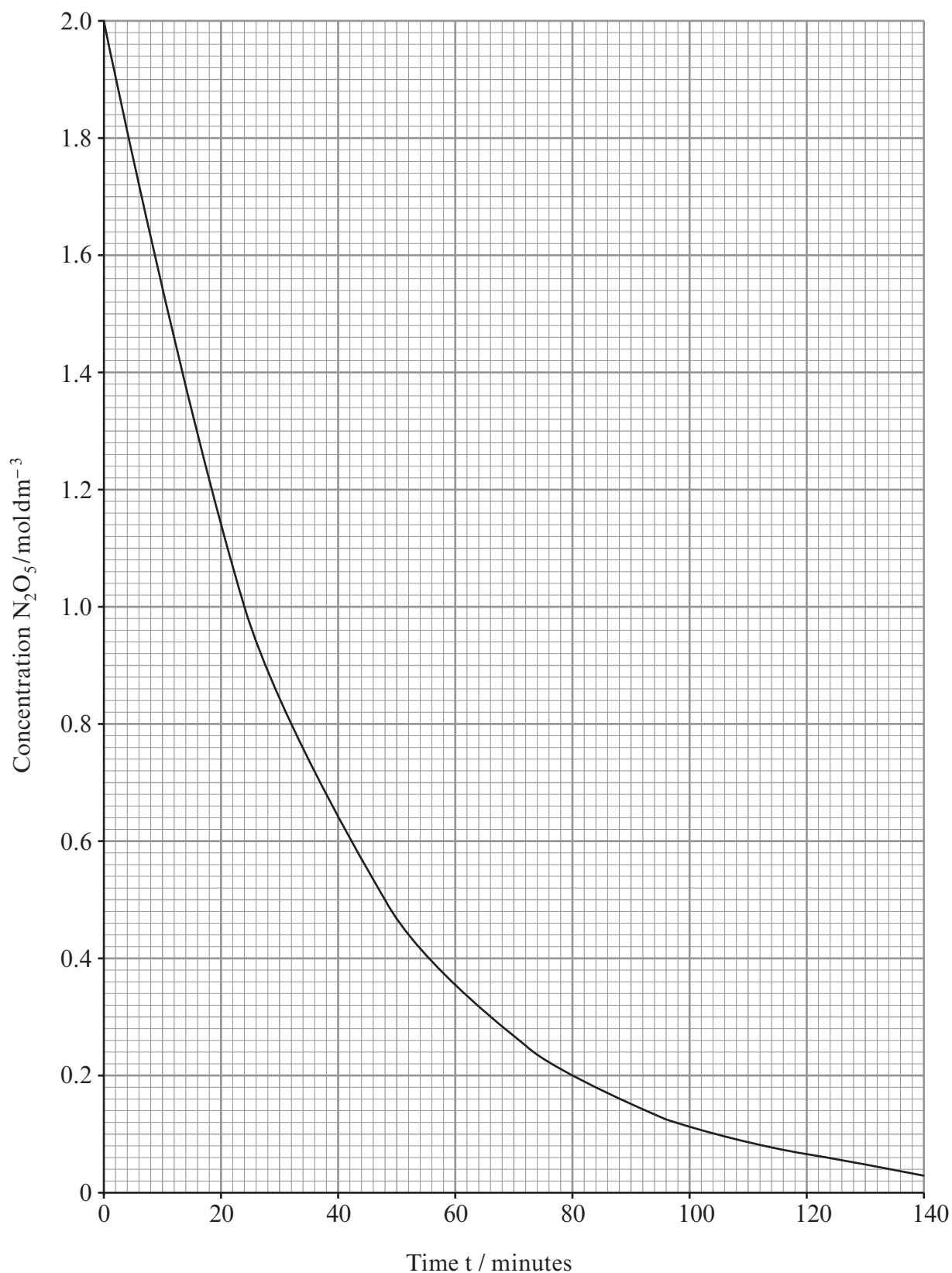


Total [14]

2. Nitrogen forms a variety of oxides including dinitrogen pentoxide,  $\text{N}_2\text{O}_5$ , which can decompose as shown in the equation.



The rate at which this decomposition occurs can be followed by measuring the change in concentration of  $\text{N}_2\text{O}_5$ . A graph of the results of this decomposition is shown below.



- (a) (i) Use the graph to determine the rate of reaction, in  $\text{mol dm}^{-3} \text{min}^{-1}$ , after 40 minutes. Show clearly on the graph, how you determined your answer. [2]

*Rate after 40 minutes* = .....  $\text{mol dm}^{-3} \text{min}^{-1}$

- (ii) Explain why the rate of reaction is lower at  $t = 60$  minutes than it was at  $t = 40$  minutes. [1]

.....

.....

.....

- (b) (i) Use the graph to show that the reaction is first order with respect to  $\text{N}_2\text{O}_5$ . Explain how you reached your conclusion. [2]

.....

.....

.....

- (ii) Write the rate equation for the reaction. [1]

.....

- (iii) Find the value of  $k$  in the rate equation and state its units. [2]

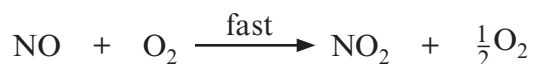
*Value of  $k$*  = .....

*Units* = .....

- (iv) Two students suggested possible mechanisms for the decomposition of  $\text{N}_2\text{O}_5$ .



**Student A**



**Student B**



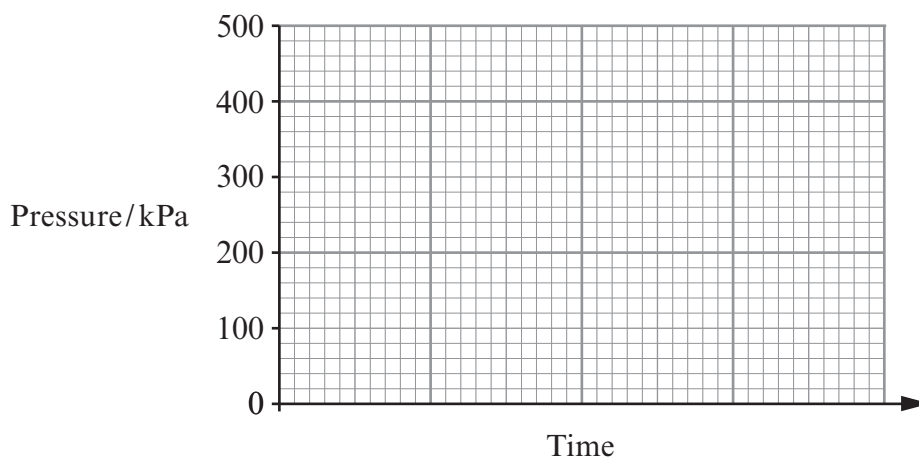
State, with a reason, which student's suggested mechanism is more likely to be correct. [1]

.....

.....

.....

- (c) The progress of the reaction could have been followed by monitoring changes in pressure. On the axes below sketch the results expected if the initial pressure of the  $\text{N}_2\text{O}_5$  was 100 kPa and the reaction reached completion. [2]



Total [11]

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3. Read the passage below and then answer the questions in the spaces provided.

### Acids Through The Ages

The ancient Greeks started to classify materials as salt-tasting, sweet-tasting, sour-tasting and bitter-tasting. In this classification acids were those considered to be sour-tasting – the name comes from the Latin *acere*.

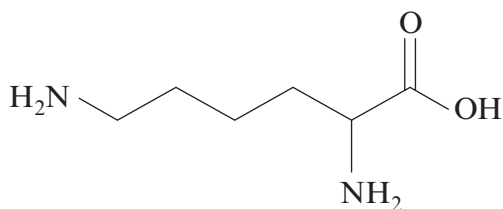
- 5 Taste continued to be an important consideration – even today many people would think of the sour taste of a lemon as being typical of an acid. However it was found that, as well as taste, these compounds had other properties in common. The dye litmus had been extracted from lichens and it was found that acids changed the colour of this to red. They also corroded metals.

- 10 Many acids were identified – citric acid could be extracted from citrus fruit and methanoic acid could be extracted, by distillation, from red ants. Methanoic acid used to be called formic acid since the biological term for an ant is *formica*.

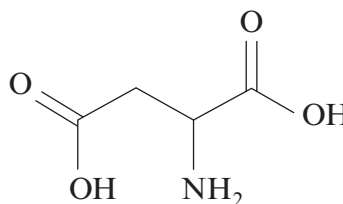
The modern classification of acids is based on the theory suggested by Lowry and Brønsted although more recent classifications, based on electron pair donation, have been suggested by Lewis.

- 15 Using the Lowry-Brønsted classification both citric acid and methanoic acid are described as being weak. For methanoic acid,  $\text{HCOOH}$ , the value of the acid dissociation constant,  $K_a$ , is  $1.75 \times 10^{-4} \text{ mol dm}^{-3}$ .

- 20 Acids have a wide variety of uses in modern chemistry. They can, for example, be used as catalysts in hydrolysis reactions and work is currently being done to investigate the possibility of obtaining biofuels by the hydrolysis of farm waste such as straw. In some situations however acids can destroy catalytic effects. The tertiary structure and therefore the shape of the active sites of some enzyme catalysts can be maintained by ionic attractions. This could arise, for example, when the enzyme involves the amino acids lysine and aspartic acid. The  $\text{NH}_2$  on the lysine can be protonated to give a positive ion, whilst the  $\text{COOH}$  can be deprotonated to give a negative ion. Attraction between oppositely charged ions holds the shape but if the pH is altered and one of the charges is lost the shape can change and the enzyme becomes denatured.



lysine



aspartic acid

- 30 The possible alteration of the shapes of molecules in biological systems means that it is important that the pH of, for example shampoos, is maintained within a small range. For best results shampoo should stay at a pH just below 7.

- End of passage -



(a) State what is meant by a Lowry-Brønsted acid. (*line 12*)

[1]

.....

.....

(b) Define pH.

[1]

.....

.....

(c) David and Peter were discussing acids and bases. David said that you could decide whether an acid was strong or weak by measuring the pH of the acid solution. He said that the strong acid would have a lower pH. Peter said that he felt that the strength of the acid was not the only factor that affected pH.

Discuss the factors that affect pH.

[4]

QWC [1]

.....

.....

.....

.....

.....

.....

(d) Methanoic acid is a weak acid.

(i) Write the expression for the acid dissociation constant,  $K_a$ , of methanoic acid. [1]

(ii) Using the information in *lines 16* and *17* of the article, calculate the pH of  $0.10 \text{ mol dm}^{-3}$  methanoic acid. [3]

pH = .....

(e) The article (*line 29*) states that it is important to maintain the pH of shampoo within a small range.

(i) What name is given to a system designed to maintain pH within a small range?

[1]

(ii) The pH of a shampoo is maintained within a small range by using a weak acid,  $\text{RCOOH}$ , and its sodium salt,  $\text{RCOONa}$ .

Explain how this mixture maintains pH within a small range.

[3]

Total [15]

**Total Section A [40]**

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## SECTION B

Answer **both** questions in the separate answer book provided.

4. (a) Electrochemical cells are used as power sources in many everyday applications. To decide what to use in a cell, it is necessary to know the standard electrode potential for electrodes. This is measured using a standard hydrogen electrode as a reference standard.

Draw a labelled diagram of the apparatus you would use to measure the standard electrode potential of an  $\text{Fe}^{3+}/\text{Fe}^{2+}$  electrode. [5]

- (b) Vanadium is a transition metal that can form compounds with a variety of oxidation states. Zinc however forms compounds with an oxidation state of +2 only.

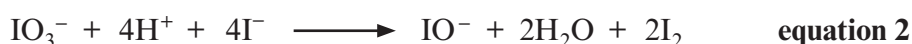
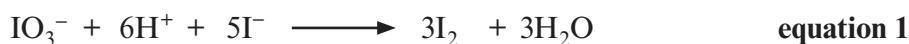
- (i) Why can transition elements form compounds with a variety of oxidation states? [1]
- (ii) Give the electronic structure of Zn. [1]
- (iii) State why zinc forms  $\text{Zn}^{2+}$ . [1]

You will need the standard electrode potentials in the table below to answer part (c).

Oxidation state of vanadium at start of reaction	Reaction	$E^\ominus/\text{V}$
+5	$\text{VO}_3^-(\text{aq}) + 4\text{H}^+(\text{aq}) + \text{e} \rightleftharpoons \text{VO}^{2+}(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$	+1.00
+4	$\text{VO}^{2+}(\text{aq}) + 2\text{H}^+(\text{aq}) + \text{e} \rightleftharpoons \text{V}^{3+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$	+0.34
+3	$\text{V}^{3+}(\text{aq}) + \text{e} \rightleftharpoons \text{V}^{2+}(\text{aq})$	-0.26
+2	$\text{V}^{2+}(\text{aq}) + 2\text{e} \rightleftharpoons \text{V}(\text{s})$	-1.13
	$\text{Zn}^{2+}(\text{aq}) + 2\text{e} \rightleftharpoons \text{Zn}(\text{s})$	-0.76
	$\text{Cu}^{2+}(\text{aq}) + 2\text{e} \rightleftharpoons \text{Cu}(\text{s})$	+0.34

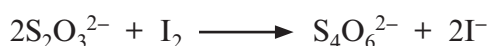
- (c) Vanadium(V)(aq), as  $\text{VO}_3^-$ , is yellow and can be reduced by zinc and aqueous acid producing a series of coloured solutions until the reduction stops with the formation of a violet solution. The reducing agent involves the  $\text{Zn}^{2+}(\text{aq})/\text{Zn}(\text{s})$  equilibrium.
- State the identity of the violet vanadium-containing solution produced in this reduction. Use standard electrode potentials to explain your answer. [3]
  - What is the standard potential of a cell formed from a standard  $\text{Zn}^{2+}(\text{aq})/\text{Zn}(\text{s})$  electrode and a standard  $\text{Cu}^{2+}(\text{aq})/\text{Cu}(\text{s})$  electrode? [1]
  - Write the equilibrium equation for the change occurring at the zinc electrode showing the direction in which the reaction proceeds. [1]
  - Use Le Chatelier's principle to predict the effect on the electrode potential of the zinc electrode of increasing the concentration of  $\text{Zn}^{2+}(\text{aq})$  in the electrode. Explain your answer. [2]
- (d) Halogens can also form compounds with a variety of oxidation states. Some of these including compounds of iodate(V),  $\text{IO}_3^-$ , behave as oxidising agents.

A student was investigating the reaction that occurs when iodate(V) oxidises iodide ions to produce iodine. Two possible equations were suggested.



He prepared a solution of potassium iodate(V) by dissolving 0.978 g of  $\text{KIO}_3$  in  $250\text{ cm}^3$  of solution. He pipetted  $25.0\text{ cm}^3$  of this solution into a conical flask, added excess potassium iodide and titrated the iodine produced with  $0.100\text{ mol dm}^{-3}$  sodium thiosulfate solution,  $\text{Na}_2\text{S}_2\text{O}_3$ . A volume of  $27.40\text{ cm}^3$  of this solution was needed to react with the iodate(V).

The equation for the reaction of thiosulfate with iodine is shown below.



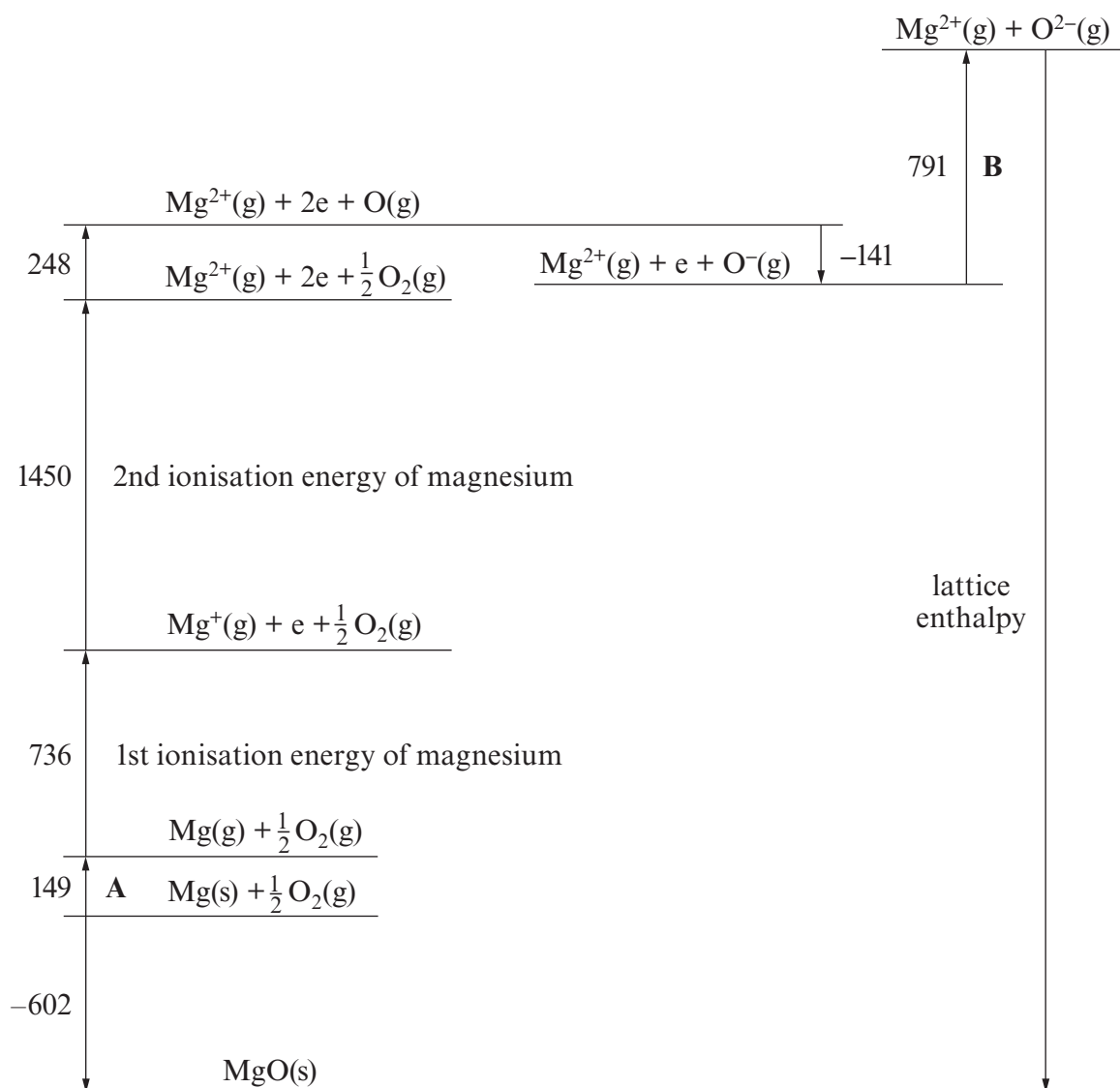
- Calculate the number of moles of thiosulfate used to react with the iodine. [1]
- Deduce the number of moles of iodine present in the  $25.0\text{ cm}^3$  sample. [1]
- Calculate the number of moles of  $\text{KIO}_3$  present in  $250\text{ cm}^3$  of the original solution and hence the number of moles present in  $25.0\text{ cm}^3$ . [1]
- Use your results from (ii) and (iii) to deduce which of **equation 1** and **equation 2** suggested above, correctly shows what happens when iodate(V) ions oxidise iodide ions. Show, by calculation, how you came to this conclusion. [2]

Total [20]

5. Magnesium oxide,  $\text{MgO}$ , is a white solid with a very high melting temperature and it is used as the refractory lining in furnaces.

(a) The following Born-Haber cycle shows the enthalpy changes involved in the formation of magnesium oxide.

All enthalpy changes are in  $\text{kJ mol}^{-1}$ . The cycle is not drawn to scale.



- What is the name given to the enthalpy change labelled **A**? [1]
- State why the second ionisation energy of magnesium is greater than its first ionisation energy. [1]
- Suggest why the second electron affinity of oxygen, labelled **B**, is positive. [1]
- Calculate the value of the lattice enthalpy for magnesium oxide. [2]

- (b) Many metal oxides can be reduced to the metal by carbon monoxide. The equation for the reduction of magnesium oxide is given below.



The conditions under which reactions will occur can be predicted using enthalpy and entropy changes. The entropies of the substances involved in this reaction are shown in the table.

Substance	MgO(s)	CO(g)	Mg(s)	CO <sub>2</sub> (g)
Entropy / JK <sup>-1</sup> mol <sup>-1</sup>	26.9	197.7	32.7	213.7

- (i) Suggest a reason why the entropies of carbon monoxide and carbon dioxide are much higher than those of magnesium and magnesium oxide. [1]
  - (ii) Calculate the entropy change in this reaction. [1]
  - (iii) The enthalpy change,  $\Delta H$ , for the reduction of magnesium oxide is 318.0 kJ mol<sup>-1</sup>. Calculate the minimum temperature at which this reduction could occur. [3]
- (c) Magnesium oxide, MgO, lead(II) oxide, PbO, and aluminium oxide, Al<sub>2</sub>O<sub>3</sub>, all react with dilute acids to form aqueous ions – Mg<sup>2+</sup>(aq), Pb<sup>2+</sup>(aq) and Al<sup>3+</sup>(aq).

Suggest tests that would enable you to distinguish between solutions containing one of each of these ions. You should include the expected result for **each** test and are advised to record your tests and expected results in a table. [5]

*QWC* [2]

- (d) Aluminium chloride, AlCl<sub>3</sub>, can be used to produce compounds including the chloroaluminate(III) ion, AlCl<sub>4</sub><sup>-</sup>.
- (i) Draw a dot and cross diagram to show the electron arrangement in the AlCl<sub>4</sub><sup>-</sup> ion. You should show outer electrons only. [1]
  - (ii) Give **one** industrially important use in which the AlCl<sub>4</sub><sup>-</sup> ion is involved. State the role of the ion in this use. [2]

Total [20]

**Total Section B [40]**

**END OF PAPER**



**GCE A level**

1095/01-A

**CHEMISTRY – CH5**

**Periodic Table**

A.M. WEDNESDAY, 19 June 2013



# THE PERIODIC TABLE

## Group

[illegible]

► Lanthanoid elements

►► Actinoid elements

140	Ce	Cerium	58
141	Pr	Praseodymium	59
144	Nd	Neodymium	60
(147)	Pm	Promethium	61
150	Sm	Samarium	62
(153)	Eu	Europium	63
157	Gd	Gadolinium	64
159	Tb	Terbium	65
163	Dy	Dysprosium	66
165	Ho	Holmium	67
167	Er	Erbium	68
169	Tm	Thulium	69
173	Yb	Ytterbium	70
175	Lu	Lutetium	71