

Candidate Name	Centre Number	Candidate Number
		2



GCE A level

335/01

CHEMISTRY CH5

A.M. THURSDAY, 18 June 2009

1 hour 40 minutes

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

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

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

Section A Answer **all** the 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 (35 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 75.

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 used in all your written answers

(c) Sodium hydride is a strong *reducing agent*.

(i) Explain the term *reducing agent*. [1]

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(ii) Sodium hydride, NaH, reacts with water. State the products of this reaction and, by using oxidation numbers, show that sodium hydride is acting as a reducing agent in this reaction. [2]

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(d) Give one test, and the expected observations, which would show the presence of sodium in a white solid such as sodium hydride. [1]

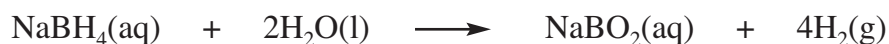
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(e) Much research is being done into the use of ionic hydrides as a source of fuel for vehicles. One such hydride is sodium tetrahydridoborate(III), NaBH₄, which can be prepared from sodium hydride.

(i) Balance the following equation by inserting numbers in the spaces.



(ii) Sodium tetrahydridoborate(III) normally reacts only very slowly with water, but in the presence of a catalyst it can be used in a vehicle to generate hydrogen gas for fuel.



Calculate the maximum volume of H₂(g) which could be generated from 1 kg of NaBH₄ at 25 °C. [2]

(1 mole of gas occupies 24 dm³ at 25 °C).

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Total [12]

Turn over.

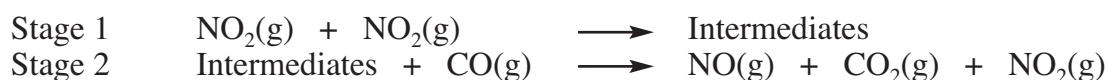
2. The gaseous reaction between carbon monoxide, CO, and nitrogen dioxide, NO₂, is shown by the equation below.



- (a) At temperatures below 500 K, experiments have shown the rate equation to be given by

$$\text{Rate} = k [\text{NO}_2]^2$$

The mechanism can be represented as two stages, one of which is the **rate determining step**:



Explain the term **rate determining step** and, giving your reasoning, state which of the above two stages is the rate determining step in this reaction. [2]

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- (b) At higher temperatures, the products are the same but the reaction proceeds by a different mechanism. Experiments at a temperature of 600 K produced the following results.

Initial Rate of Reaction / mol dm ⁻³ s ⁻¹	Initial Concentration NO ₂ [NO ₂] / mol dm ⁻³	Initial Concentration CO [CO] / mol dm ⁻³
1.12 × 10 ⁻⁴	0.050	0.050
2.24 × 10 ⁻⁴	0.050	0.100
4.48 × 10 ⁻⁴	0.100	0.100
8.96 × 10 ⁻⁴	0.100	0.200

- (i) Determine the order of reaction with respect to NO₂ and the order with respect to CO and state the rate equation for this reaction at 600 K. [3]

NO₂ order CO order

Rate equation

- (ii) Calculate the value of the rate constant, k , at 600 K, and give its units. [2]

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- (iii) Suggest a rate-determining step which fits the rate equation at 600 K. [1]

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- (c) Nitrogen monoxide, NO, can be formed in small amounts when a mixture of nitrogen and oxygen is exposed to strong heat.



- (i) Write the expression for the gaseous equilibrium constant, K_p , for this reaction. [1]

- (ii) At a temperature of 1500 K, K_p has a value of 1.0×10^{-5} . Calculate the partial pressure (in atm) of nitrogen monoxide, NO, present at equilibrium if the partial pressures of nitrogen and oxygen at equilibrium are each 1.2 atm. [2]

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- (iii) At a temperature of 1100 K, K_p has a value of 4.0×10^{-8} . State, giving your reasoning, whether the reaction to form nitrogen monoxide is exothermic or endothermic. [1]

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Total [12]

Turn over.

3. (a) Ethanoic acid, CH_3COOH , is a *weak acid*.

(i) Explain the meanings of *weak* and *acid* in this context. [2]

Weak

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Acid

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(ii) Write an expression for the *acid dissociation constant*, K_a , for ethanoic acid. [1]

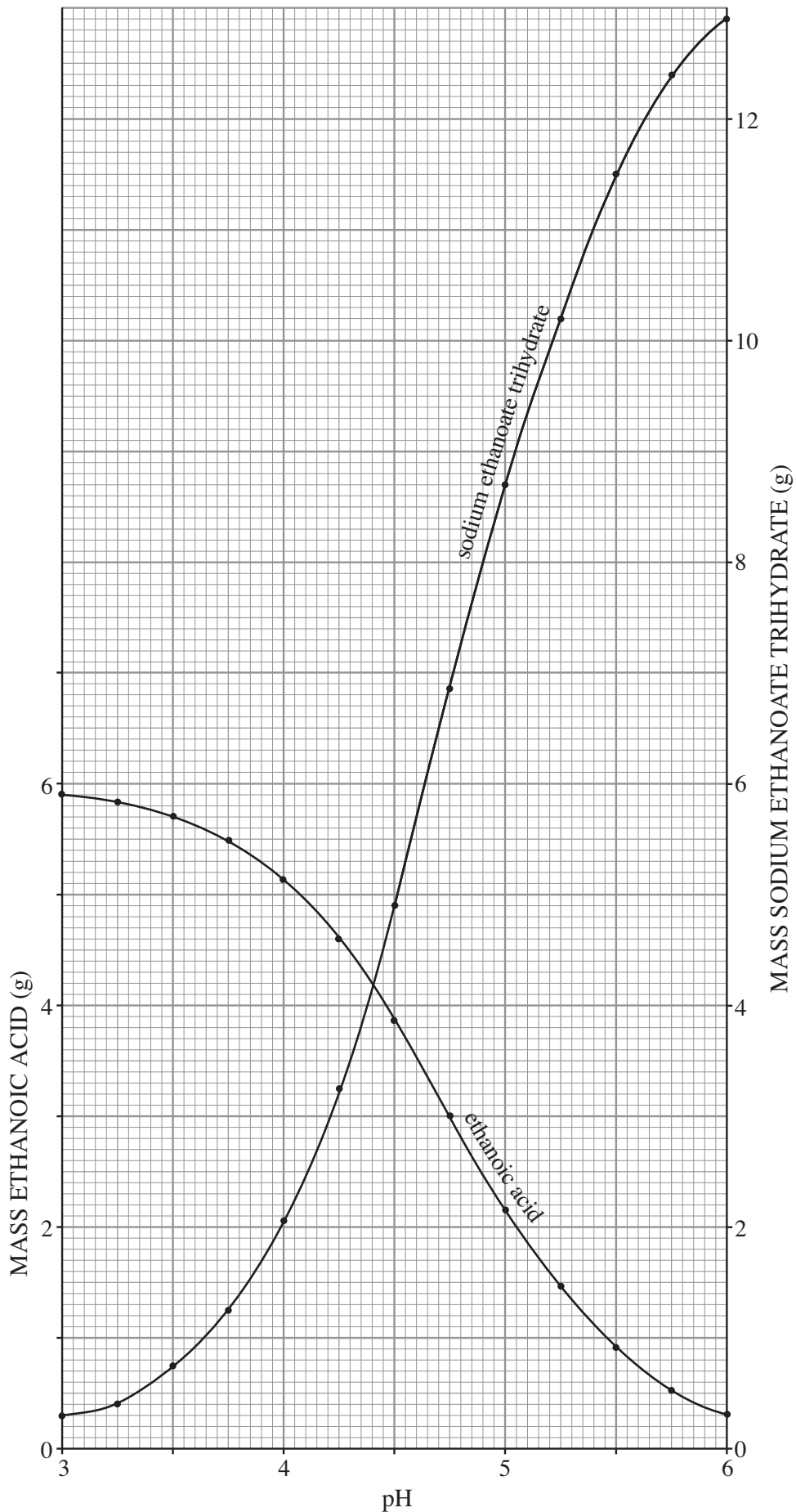
(b) A solution containing a mixture of ethanoic acid and sodium ethanoate trihydrate behaves as a buffer. The graph opposite can be used to determine the masses of ethanoic acid (CH_3COOH) and sodium ethanoate trihydrate ($\text{CH}_3\text{COONa}\cdot 3\text{H}_2\text{O}$), which, when made up together to 1 dm^3 solution, give a buffer with a desired pH.

(i) From the graph, determine the masses of ethanoic acid and sodium ethanoate trihydrate which give a pH of 4.0 when dissolved in 1 dm^3 solution. [1]

Mass ethanoic acid g

Mass sodium ethanoate trihydrate g

GRAPH TO CALCULATE MASSES OF ETHANOIC ACID AND SODIUM ETHANOATE TRIHYDRATE DISSOLVED IN 1 dm^3 OF SOLUTION TO MAKE BUFFER OF A CERTAIN pH



- (ii) Calculate the molar masses, M_r , for each of ethanoic acid (CH_3COOH) and sodium ethanoate trihydrate ($\text{CH}_3\text{COONa}\cdot 3\text{H}_2\text{O}$). [1]

CH_3COOH

.....

$\text{CH}_3\text{COONa}\cdot 3\text{H}_2\text{O}$

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- (iii) Using your answers to (b)(i) and (ii), calculate the concentrations (mol dm^{-3}) of the ethanoic acid and sodium ethanoate trihydrate solutions in the buffer solution with pH 4.0. [1]

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- (iv) State the hydrogen ion concentration, $[\text{H}^+(\text{aq})]$, in a solution of pH 4.0. [1]

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- (v) Use your answers to (b)(iii) and (iv) to calculate the value of the acid dissociation constant, K_a , for ethanoic acid. Give the units of K_a . [1]

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- (c) Explain why a mixed solution of ethanoic acid and sodium ethanoate behaves as a buffer solution. [3]

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Total [11]

Section A Total [35]

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SECTION B

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

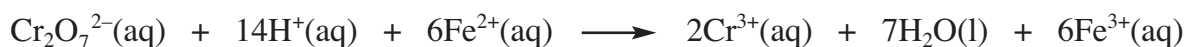
4. (a) The table shows a section of the Periodic Table together with the maximum covalency for each element. Maximum covalency is the highest number of covalent bonds formed by each element, **excluding** coordinate covalent bonds.

<i>Group III</i>	<i>Group IV</i>	<i>Group V</i>	<i>Group VI</i>
B	C	N	O
3	4	3	2
Al	Si	P	S
3	4	5	6

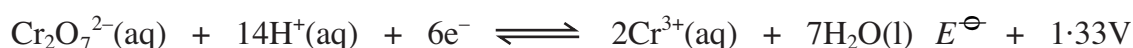
- (i) Explain why B and Al are both limited to a maximum covalency of 3 and why their compounds are *electron deficient*. [2]
- (ii) Explain the decrease in maximum covalency along the row, C, N and O. [2]
- (iii) Explain why N has a maximum covalency of 3 but P in the same group has a maximum of 5. [2]
- (b) Compare and contrast the reactions, if any, of sodium chloride, NaCl, and sodium iodide, NaI, in each of the following parts (i) to (iii). Your answers should include:
- the expected observations in each case and the species responsible;
 - when appropriate, how the observations relate to the redox trends within Group VII;
 - appropriate equations for parts (i) and (iii) (equations not required for part (ii)).
- (i) the addition of $\text{Pb}^{2+}(\text{aq})$ to aqueous solutions of sodium chloride and sodium iodide; [3]
- (ii) the slow addition of concentrated sulphuric acid, with gentle warming, to solid samples of sodium chloride and sodium iodide; [4]
- (iii) the addition of bromine water to aqueous solutions of sodium chloride and sodium iodide. [3]
- (c) Aluminium oxide, Al_2O_3 , is an *amphoteric* oxide. Explain the meaning of the term *amphoteric* and give **two** reactions, including equations, which demonstrate the amphoteric behaviour of aluminium oxide. [4]

Total [20]

5. (a) Dichromate(VI) ions, $\text{Cr}_2\text{O}_7^{2-}$, react with iron(II) ions in acid solution according to the following equation.



This reaction can be used as the basis of an electrochemical cell where the standard electrode potentials of the two half reactions are shown below.



- (i) Calculate the EMF of the cell. [1]
- (ii) Platinum electrodes are used in the cell. Explain the purpose of these platinum electrodes. [1]
- (iii) Draw a labelled diagram to show a possible construction for the cell. Your labels should include:
- the apparatus used;
 - the reagents;
 - the positive and negative electrodes;
 - the direction of electron flow in the circuit. [5]
- (iv) State the colour change which will occur at each of the two electrodes when the cell is operating. [2]
- (v) The same reaction can be used to determine the concentration of $\text{Fe}^{2+}(\text{aq})$ by titrating against standard potassium dichromate(VI) solution. In one experiment, after the electrochemical cell above had been operating for a period of time, a 25.0 cm^3 sample of the solution from the iron electrode was titrated against $0.0250 \text{ mol dm}^{-3}$ potassium dichromate(VI) solution in excess acid, when 12.5 cm^3 potassium dichromate(VI) solution was required to reach the end point.



- I. Calculate, to three significant figures, the concentration of the $\text{Fe}^{2+}(\text{aq})$ solution after operating the cell for the same period of time. [3]
- II. If, at the start, the electrode solution had contained $0.100 \text{ mol dm}^{-3}$ $\text{Fe}^{2+}(\text{aq})$ and $0.100 \text{ mol dm}^{-3}$ $\text{Fe}^{3+}(\text{aq})$, calculate the $\text{Fe}^{3+}(\text{aq})$ concentration after operating the cell for the same period of time. [1]

Turn over for parts (b), (c) and (d).

- (b) State the full electron configurations of
- (i) Chromium metal, Cr (ii) Chromium(III) ion, Cr^{3+} [2]
- (c) The octahedral complex ion $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$ is violet. Explain how the colour arises in this complex ion. [4]
- (d) Like many other transition metals, chromium is important as a trace element in living systems. Give **one** example of the importance of chromium, or another transition metal of your choice, as a trace element in living systems. [1]

Total [20]

Section B Total [40]