

CHEMISTRY

CH5

SPECIMEN PAPER

(1hr 45min)

**ADDITIONAL MATERIALS**

In addition to this examination paper, you will need

- a calculator
- an 8 page answer book
- a Periodic Table supplied by WJEC

**INSTRUCTIONS TO CANDIDATES**

Answer all questions.

Write your answers to Section A in the spaces provided in this booklet.

Write your answers to Section B in the separate answer book provided.

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

**INFORMATION FOR CANDIDATES**

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

You are reminded that the quality of written communication used in your answers will be important in accessing the marks allocated, especially where the letters QWC appear at the end of a question.

No certificate will be awarded to a candidate detected in any unfair practice during the examination.

You are reminded that this paper is synoptic and so will test understanding of the connections between the different elements of the subject.

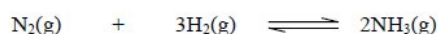
SECTION A

Answer all the questions in the spaces provided.

1. (a) Explain the term *dynamic equilibrium*. [1]

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- (b) At a given fixed temperature, for the reaction



the equilibrium constant,  $K_c$ , =  $0.50 \text{ mol}^2 \text{ dm}^{-6}$ .

- (i) Write an expression for  $K_c$ . [1]

- (ii) If 2.0 mol of nitrogen gas and 4.0 mol of hydrogen gas are in equilibrium with ammonia in a  $2.0 \text{ dm}^3$  flask at this temperature,

- I find the equilibrium concentration of ammonia,  $\text{NH}_3$ , in  $\text{mol dm}^{-3}$ , [2]

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.....

- II calculate the percentage of the total nitrogen in the system present as  $\text{N}_2$  gas at equilibrium. [2]

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.....

- (c) Measurements on the rate of the reaction



showed that when the partial pressure of NO,  $p_{\text{NO}}$ , was doubled at constant partial pressure of chlorine,  $p_{\text{Cl}_2}$ , the initial rate of reaction increased by a factor of 4 and the initial rate of reaction increased by a factor of 8 when the partial pressures  $p_{\text{NO}}$  and  $p_{\text{Cl}_2}$  were both doubled.

- (i) Deduce the order of reaction with respect to NO. [1]

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.....

(ii) Deduce the order of reaction with respect to  $\text{Cl}_2$ . [1]

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(iii) Deduce the overall order of the reaction. [1]

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.....

(iv) Given that the forward reaction is thought to occur in a single step, draw in the space below the most likely transition state for the reaction. [2]

(d) Consider the effect of a temperature increase and the addition of a catalyst on the properties of a reaction by inserting increase (I), decrease (D), or no effect (NE) in the table. [2]

<i>Property of the reaction</i>	<i>Temperature increase</i>	<i>Addition of a catalyst</i>
Activation energy of the forward reaction		
The rate of the forward reaction		

Total [13]

2. (a) (i) Describe the action of chlorine on aqueous sodium hydroxide, giving the appropriate reaction conditions and writing a balanced equation for each reaction which occurs. [4]

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- (ii) Illustrate the variable oxidation states of chlorine by giving two species from your answer to (a)(i) in which chlorine has different oxidation states. Give the appropriate oxidation states. [2]

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- (b) (i) Explain why lead forms a stable  $\text{Pb}^{2+}$  ion but carbon does not form a corresponding  $\text{C}^{2+}$  ion. [2]

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- (ii) For each of the following, describe the observation(s) and write balanced equations for the reactions occurring:

I excess sodium hydroxide solution is added to a solution containing  $\text{Pb}^{2+}(\text{aq})$  ions; [3]

.....

.....

II potassium iodide is added to a solution containing  $\text{Pb}^{2+}(\text{aq})$  ions. [2]

.....

.....

Total [13]

3. Read the passage below and then answer the questions (a) to (f) in the spaces provided.

Ethanoic acid is a typical carboxylic acid, which has been known for thousands of years. The common name for ethanoic acid is *acetic acid*, a name derived from the Latin for vinegar, *acetum*.

Ethanoic acid is a weak acid in aqueous solution. ( $K_a = 1.78 \times 10^{-5} \text{ mol dm}^{-3}$  at 298 K). An equilibrium exists in aqueous solution and the equation representing this is: 5



Traditionally, ethanoic acid was determined by titration against alkali using the colour change of an indicator to find the end point. Today, to allow automation of the process, the titration is often performed by using a pH meter connected to a computer to find the end-point. 10

When a strong acid such as hydrochloric acid is titrated against alkali such as sodium hydroxide, there is a jump of 8 to 10 pH units at the end-point, and the pH at the end-point is 7. For a weak acid titrated against sodium hydroxide, the pH jump is smaller and the end-point pH is usually in the range 8 to 9.

An aqueous solution containing equimolar amounts of ethanoic acid and sodium ethanoate,  $\text{CH}_3\text{COO}^-\text{Na}^+$ , acts as a buffer solution. 15

A dilute solution of the acid is used as vinegar. A typical domestic brown malt vinegar is labelled as 5% acidity, that is, 5 g of acid per  $100 \text{ cm}^3$  of solution.

The annual world production of ethanoic acid is in excess of six million tonnes per year. To meet world demand, modern production methods have been devised, for example, the direct combination of carbon monoxide and methanol at moderate temperature (450 K) and pressure (30 atm) with a rhodium-iodine catalyst. This exothermic reaction gives a yield of over 99%, whereas earlier processes produced up to 40% of by-products. 20

Most of the ethanoic acid manufactured is converted into other useful substances such as esters (flavourings, solvents etc.), cellulose ethanoate (rayon fibres) and PVA (adhesives). Very little of it ends up on chips! 25

– End of passage –

- (a) Explain the term *weak acid*. [1]

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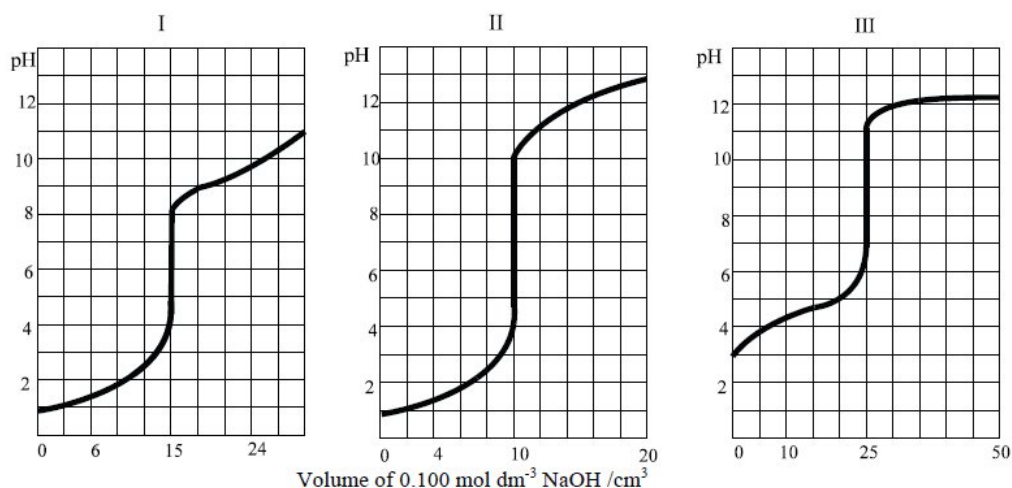
- (b) Write the expression for the acid dissociation constant,  $K_a$ , of ethanoic acid,  $\text{CH}_3\text{COOH}$ . (line 6). [1]

$K_a =$

- (c) The dissociation constant,  $K_a$ , for benzenecarboxylic (benzoic acid) is  $6.31 \times 10^{-5} \text{ mol dm}^{-3}$  at 298 K.  
 State, giving a reason, whether ethanoic acid is a stronger or weaker acid than benzoic acid (line 4). [1]

.....  
 .....

- (d) The pH titration curves shown below are for the titration of  $20.0 \text{ cm}^3$  of aqueous acid with aqueous NaOH of concentration  $0.100 \text{ mol dm}^{-3}$ ;



With brief reasons (lines 11-14),

- (i) give the number of the titration curve which represents hydrochloric acid v sodium hydroxide, [2]

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 .....

- (ii) give the number of the titration curve which represents ethanoic acid v sodium hydroxide, [2]

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 .....

- (iii) state the number of the titration in which the most concentrated acid was used, [2]

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 .....

(iv) calculate the concentration of the acid in (iii). [2]

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.....

(e) Explain what is meant by a *buffer solution* (line 16). [1]

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(f) Calculate the concentration, in  $\text{mol dm}^{-3}$ , of ethanoic acid in brown malt vinegar (lines 17-18). [2]

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Total [14]

5. (a) Four standard electrode potentials (A to D) are listed below.

Half equation	$E^\ominus / \text{V}$
A $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightleftharpoons 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	+1.33
B $\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}$	+1.23
C $\text{Fe}^{3+} + \text{e}^- \rightleftharpoons \text{Fe}^{2+}$	+0.77
D $2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2$	0

- (i) Explain why potential D has a value of zero. [2]
- (ii) Use A and C to show that acidified dichromate oxidises iron(II) to iron(III) and write a balanced equation for the reaction. [2]
- (iii) If a student titrated three  $25.0 \text{ cm}^3$  samples of a solution containing  $\text{Fe}^{2+}$  ions against a standard  $0.0200 \text{ mol dm}^{-3}$  potassium dichromate solution, obtaining titres of  $26.00 \text{ cm}^3$ ,  $26.05 \text{ cm}^3$  and  $26.50 \text{ cm}^3$  respectively, calculate the concentration of the  $\text{Fe}^{2+}$  solution in  $\text{mol dm}^{-3}$  to three significant figures. [2]
- (iv) If the  $\text{Fe}^{2+}$  solution was prepared by dissolving ammonium iron(II) sulfate crystals,  $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ , in water, calculate the concentration of ammonium iron(II) sulfate in  $\text{g dm}^{-3}$ . [2]
- (v) Use B and C to explain why  $\text{Fe}^{2+}$  ions are not stable in water containing dissolved air. [2]
- (vi) Explain how B and D form the basis of a hydrogen fuel cell. [3]
- (vii) State one advantage and one disadvantage of using hydrogen fuel cells as a source of power and heat. [2]
- (b) (i) State the full electron subshell configurations for the  $\text{Fe}^{2+}$  ion and explain why iron is able to form more than one stable cation. [3]
- (ii) State the shapes of the  $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$  and  $[\text{FeCl}_4]^-$  complex ions, which are based on the same shapes as the corresponding copper(II) complexes. [2]

Total [20]