Centre Number	Candidate Number	Name

CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CHEMISTRY **9701/04**

Paper 4 Structured Questions A2 Core

October/November 2003

1 hour

Candidates answer on the Question Paper.
Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, Centre number and candidate number in the spaces at the top of this page.
Write in dark blue or black pen in the spaces provided on the Question Paper.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
You may lose marks if you do not show your working or if you do not use appropriate units.

If you have been given a label, look at the details. If any details are incorrect or missing, please fill in your correct details in the space given at the top of this page.

Stick your personal label here, if provided.

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1 The reaction between iodine and propanone is catalysed by hydrogen ions.

$$CH_3COCH_3 + I_2 \xrightarrow{H^+} CH_3COCH_2I + HI$$

The reaction is found to be first order with respect to $[CH_3COCH_3]$ and with respect to $[H^+]$, and zero order with respect to $[I_2]$.

(a) What do you understand by the term *order of reaction*?

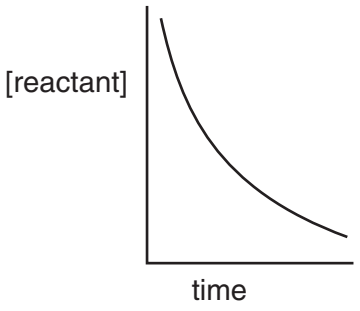
.....

.....[1]

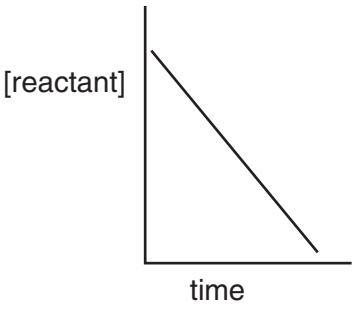
(b) Construct a rate equation for the reaction.

.....[1]

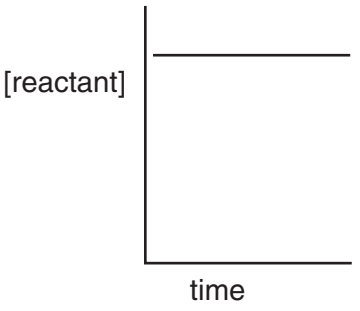
The following sketches show three ways in which the concentration of reagents might vary during the reaction.



A



B



C

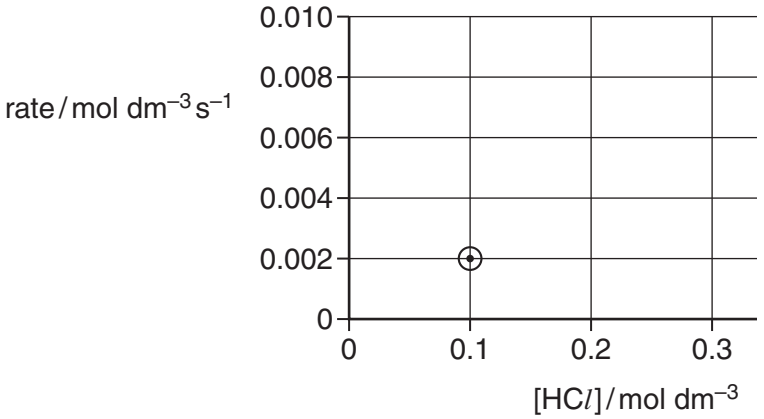
(c) Which of the above graphs correctly describes how the concentration of reactant changes with time for

(i) the propanone concentration, _____

(ii) the iodine concentration? _____

[2]

(d) When carried out in 0.1 mol dm^{-3} HCl solution, the rate was found to be 0.002 mol dm^{-3} s^{-1}. Predict the rate of reaction in 0.2 mol dm^{-3} HCl and in 0.3 mol dm^{-3} HCl solution. Plot your figures on the following graph, and draw a line through the points.



[2]

(e) Only one of the following outline reaction mechanisms is consistent with the observed kinetics.

A
$I_2 + H^+ \longrightarrow$ intermediate [slow]
intermediate + $CH_3COCH_3 \longrightarrow$ products [fast]

B
$CH_3COCH_3 + H^+ \longrightarrow$ intermediate [slow]
intermediate + $I_2 \longrightarrow$ products [fast]

C
$CH_3COCH_3 + H^+ \longrightarrow$ intermediate [fast]
intermediate + $I_2 \longrightarrow$ products [slow]

D
$CH_3COCH_3 + I_2 \longrightarrow$ intermediate [slow]
intermediate + $H^+ \longrightarrow$ products [fast]

Decide which mechanism is consistent, explaining the reasons for your choice.

Mechanism letter (**A, B, C** or **D**) _____

Reasons

.....

.....

.....

.....[3]

(f) When the starting concentrations of propanone, iodine and H^+ were 0.20 mol dm^{-3}, 0.01 mol dm^{-3} and 0.5 mol dm^{-3} respectively, the rate of decrease of $[I_2]$ was found to be 3.3 x 10^{-6} mol dm^{-3} s^{-1}.

(i) Suggest a method you could use to measure $[I_2]$.

.....

(ii) Use these figures and your rate equation in part **(b)** to calculate a value for the rate constant *k*.

.....

(iii) What are the units of *k*?

.....

[3]

[Total : 12]

2 **(a)** Methanoic acid, HCO_2H, is a weak acid, with K_a = 1.77 x 10^{-4} mol dm^{-3}.

(i) Write an expression for the K_a of methanoic acid.

.....

(ii) Use your expression to calculate the $[H^+]$ in a 0.0500 mol dm^{-3} solution of methanoic acid.

.....

(iii) Calculate the percentage of HCO_2H molecules that are ionised in this solution.

(iv) Calculate the pH of this solution.

.....

[4]

(b) Calculate the pH of a 0.0500 mol dm^{-3} solution of the strong acid HC*l*.

.....[1]

(c) Both HCO_2H and HC*l* react with powdered magnesium metal, giving off hydrogen gas. For a fixed amount of magnesium, the rate equation for the reaction is as follows.

$$\text{rate} = k[H^+(aq)]$$

(i) Write an equation for the reaction between HCO_2H and Mg.

.....

When 20.0 cm^3 of a 0.0500 mol dm^{-3} solution of either acid is reacted with an excess of powdered magnesium, the same volume of hydrogen is given off, but the methanoic acid solution reacts much more slowly than the hydrochloric acid.

(ii) Calculate the volume of hydrogen given off.

.....

(iii) Explain why the hydrogen is evolved more slowly from the methanoic acid solution.

.....

.....

(iv) Explain why, eventually, the methanoic acid solution produces just as much hydrogen as the hydrochloric acid solution.

.....

.....

.....[5]

[Total : 10]

3 Potassium manganate(VII) and potassium dichromate(VI) are both used as oxidising agents in acidic solution.

(a) Using data from the *Data Booklet*, write *either* ionic *or* full equations for the reaction between

(i) $KMnO_4$ and $FeSO_4$ in dilute H_2SO_4,

(ii) $K_2Cr_2O_7$ and SO_2 in dilute H_2SO_4.

[3]

(b) $KMnO_4$ is often used in titrations to estimate reducing agents. It is added from a burette to a solution of the reducing agent.

(i) What colour is $KMnO_4$ solution?

.....

(ii) How is the end point in the titration recognised?

.....

(iii) A solution of 0.010 mol dm^{-3} $KMnO_4$ was used to estimate the amount of $FeSO_4$ in an iron dietary supplement tablet. The tablet was crushed under dilute H_2SO_4 and the $KMnO_4$ solution was added from the burette. It was found that 14.00 cm^3 were required.

Calculate the mass of $FeSO_4$ in the tablet.

.....

.....

.....

.....

[5]

(c) Patients are prescribed iron dietary supplement tablets to cure anaemia, which is a deficiency of haemoglobin in the blood.

(i) Describe the function of haemoglobin, and how the iron atoms it contains carry out that function.

.....

.....

.....

(ii) Explain why even a **small** amount of carbon monoxide in the bloodstream is poisonous.

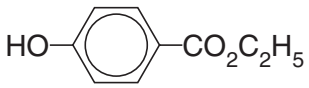
.....

.....

[3]

[Total : 11]

4 Ethyl 4-hydroxybenzoate, **E**, is a permitted food preservative.



E

(a) Name **two** functional groups in **E.**

.....

.....[2]

(b) Draw the structures of the compounds formed when **E** reacts with

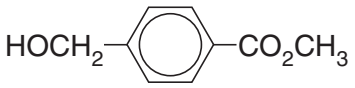
(i) sodium metal,

(ii) NaOH(aq) under reflux,

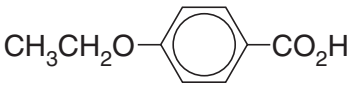
(iii) Br_2(aq).

[4]

(c) Compounds **F** and **G** are isomers of **E**.



F



G

(i) Suggest the order of acid strength of **E, F** and **G**.

.....

.....

(ii) Based on their relative acidities, suggest how samples of **E**, **F** and **G** could be distinguished from each other by the use of NaOH(aq) and Na_2CO_3(aq).

.....

.....

.....

.....

.....

[3]

[Total : 9]

5 The amino acid alanine, **K**, can be obtained from 2-hydroxypropanoic acid, **H**, by the following route.

$$CH_3CH(OH)CO_2H \xrightarrow{I} CH_3CHClCO_2H \xrightarrow{II} CH_3CH(NH_2)CO_2H$$

H **J** **K**

(a) Suggest a test you could use to distinguish **H** from its isomer 3-hydroxypropanoic acid, **L**.

$$HOCH_2CH_2CO_2H$$
L

reagents .....

observation with **H** .....

observation with **L** .....[2]

(b) How would the acidity of chloropropanoic acid, **J**, compare with that of propanoic acid? Briefly explain your answer.

.....

.....

.....[2]

(c) Alanine reacts with both acids and bases.

Write an equation for the reaction between alanine and sodium hydroxide, drawing the displayed formula of the organic product.

[2]

(d) In solution, alanine exists as a zwitterion. Draw the structure of this ion.

[1]

(e) Alanine is one of about 20 amino acids that make up proteins.

(i) What type of bond joins amino acids together in proteins?

.....

(ii) Draw the displayed formula of the compound formed when two alanine molecules are joined by this bond.

[2]

(f) An excess of benzoic acid in the body (present as a preservative in many foodstuffs, or formed by oxidation of aromatic compounds present in food) is excreted as hippuric acid, **M.**



M

(i) Suggest a reagent that could be reacted with glycine in the laboratory to form hippuric acid.

.....

(ii) Suggest the reagents and conditions needed to re-form glycine from hippuric acid.

.....

.....

[3]

[Total : 12]

6 Many millions of tonnes of limestone, $CaCO_3$, are quarried each year for use in the steel industries of the world, and in agriculture. For use in agriculture, the limestone is often decomposed by heating it in limekilns, and then adding water.

(a) Write balanced equations representing the following two processes.

(i) heating limestone

.....

(ii) then adding water

.....

[2]

(b) Describe the agricultural use of the product of this process.

.....

.....

[1]

(c) Describe and explain the trend observed in the thermal stabilities of the carbonates of Group II.

.....

.....

.....

.....

[3]

[Total : 6]