Class Adm No

Candidate Name: _____

H

millennia institute

2017 Preliminary Examination II
Pre-University 3

H2 CHEMISTRY **9647/02**

Paper 2 Structured Questions **12th Sept 2017**

2 hours

Candidates answer on the Question paper.

Additional materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Do not turn over this question paper until you are told to do so

Write your name, class and admission number on all the work you hand in.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions.

The use of an approved scientific calculator is expected, where appropriate.

A Data Booklet is provided.

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.

Question	1	2	3	4	5	Total
Marks	/12	/14	/15	/11	/20	/72

1 Planning (P)

Hydrogen peroxide undergoes a redox reaction with acidified $KMnO_4$ as follows:

$$2MnO_4^-(aq) + 5H_2O_2(aq) + 6H^+(aq) \rightarrow 2Mn^{2+}(aq) + 5O_2(aq) + 8H_2O(l)$$

By itself, hydrogen peroxide decomposes slowly in accordance to the following equation:

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

It is found that the decomposition reaction is first order with respect to H_2O_2. The reaction can be accelerated by using solid manganese(IV) oxide as the catalyst.

(a) Write the rate equation for the decomposition of hydrogen peroxide.

…… [1]

(b) Using the information given, you are required to write a plan to determine the rate constant for the decomposition of hydrogen peroxide using the continuous titration method.

You may also assume that you are provided with:

- 250 cm^3 of 0.0100 mol dm^{-3} acidified $KMnO_4$;
- 250 cm^3 of 0.0250 mol dm^{-3} H_2O_2 solution;
- Solid manganese(IV) oxide;
- 25.0 cm^3 pipette;
- Stopwatch;
- the apparatus normally found in a school or college laboratory.

Your plan should include:

- practical details of how you would
  - determine if dilution of the reaction mixture is needed for titration against H_2O_2;
  - ensure the reaction is complete;
  - carry out the titration;
- a sketch of the graph you would expect to obtain;
- brief, but specific, details of how the results would then be used to obtain
  - the initial rate of reaction of decomposition in mol dm^{-3} $min^{-1,}$
  - the rate constant for the reaction

.... [11]

[Total: 12]

2 Hydrogen iodide can undergo decomposition to give a mixture of hydrogen gas and iodine gas.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g) \qquad \Delta H = +12.0 \text{ kJ mol}^{-1}$$

(a) State Le Chatelier's Principle.

……

…… [1]

(b) Predict and explain the effect of the following changes on the position of the above equilibrium, if any.

(i) Increasing the temperature

……

……

…… [2]

(ii) Reducing the pressure

……

……

…… [1]

(iii) Addition of catalyst

……

……

…… [1]

(c) When 1.4 mol of hydrogen iodide is heated in a closed vessel at 550 K, the total pressure at equilibrium was 6 atm.

Given that the mole ratio of hydrogen iodide to iodine gas at equilibrium is 9:4, calculate the equilibrium constant, K_p, at 550 K.

[3]

(d) Hydrogen chloride and hydrogen bromide also undergoes a similar decomposition to give hydrogen gas and its respective halogens.

Describe the trend in the volatility and colours of the halogens.

……

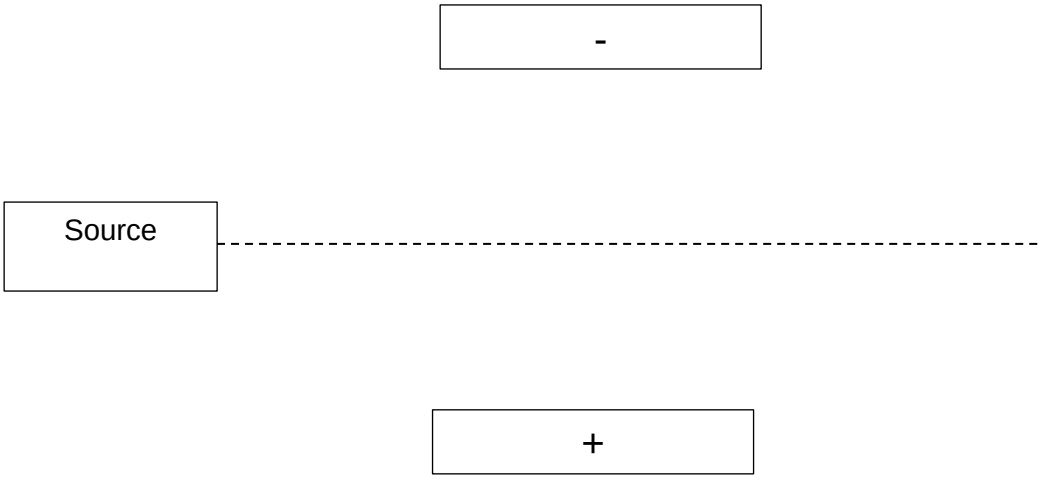
……

……

……[3]

(e) It was observed that a beam of protons gives an angle of 27° in the following electric field.

Indicate on the diagram below how a beam of protons, $^{127}I^-$ and $^{23}Na^+$ ions, travelling at the same speed, behave in the same electric field. Calculate the respective angles of deflection.

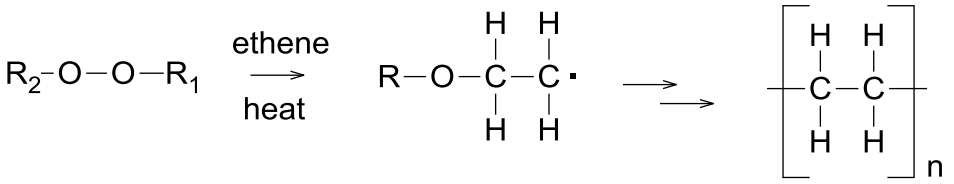


Working:

[3]

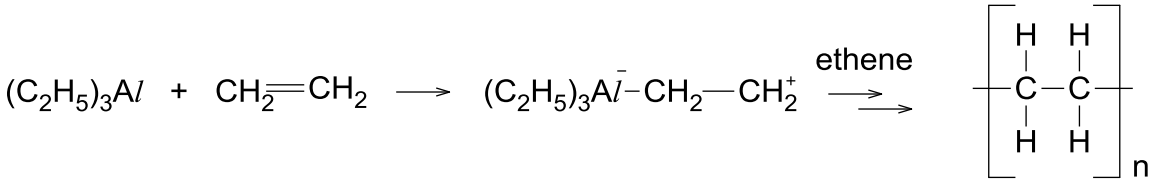
[Total: 14]

3 In 1933, chemists in Britain discovered that when ethene was subjected to high pressures in the presence of a trace amount of oxygen or organic peroxide, it produced low-density poly(ethene) (LDPE). The radical mechanism using organic peroxides is shown below.



LDPE

Using triethylaluminium, also known as Ziegler-Natta catalyst, developed by Karl Ziegler and Giulio Natta in 1953, ethene can be polymerised at much lower pressures to produce high-density poly(ethene) (HDPE). In the first step, triethylaluminium can accept the pair of π electrons of ethene to form a carbocation which is very similar to that found in the usual electrophilic addition reactions. This carbocation then undergoes an addition reaction with another ethene molecule. Eventually, long chains of ethene units form.



HDPE

The major differences between the structures of LDPE and HDPE are that

- the average chain length of LDPE is much shorter than that of HDPE
- the chains of LDPE are branched, while the chains of HDPE are unbranched.

The table below compares the physical properties of LDPE and HDPE.

Property	**Polymer**	
	LDPE	**HDPE**
Density	Low	High
Melting Point	Approximately 130 °C	Approximately 160 °C
Tensile strength	Low	High
Flexibility	Very flexible	Much more rigid

(a) **(i)** Using structure and bonding, explain the difference in melting point between LDPE and HDPE.

……

……

……

…… [2]

(ii) Suggest why LDPE has a lower density than HDPE.

……

……

……

…… [1]

(b) **(i)** Write an equation to represent the first step in the radical mechanism.

…… [1]

(ii) With reference to the mechanism given, explain why the production of LDPE only starts upon heating.

……

…… [1]

(iii) Suggest why the chains of LDPE are branched.

……

…… [1]

(c) **(i)** State the role of triethylaluminium in the reaction using Ziegler-Natta catalysts.

…… [1]

(ii) Similar to ethene, propene can be polymerised using the Ziegler-Natta catalysts. Show the structure of the carbocation intermediate formed in the first step.

[1]

(d) **Use the table of characteristics values for the infra-red absorption in the Data Booklet to answer this question.**

Infra-red absorptions can be used to identify functional groups in organic compounds. For example, ethanol shows absorptions at 1000-1300 cm^{-1} and 3230-3550 cm^{-1}.

Use the table to identify the infra-red absorption range that will be shown by

(i) Ethene but not by poly(ethene)

…… cm^{-1}

(ii) Propyl ethanoate but not by propene

…… cm^{-1}

[3]

(e) The four methods used to dispose polymers are incineration, recycling, depolymerisation and bacterial fermentation.

(i) Combustion of the polymers during incineration can lead to the formation of pollutants such as carbon monoxide which is toxic to humans, if the conditions are not carefully controlled.

In terms of the bonding involved, explain how carbon monoxide prevents oxygen from being transported around the body.

……

……

……

…… [2]

(ii) State two advantages of recycling.

……

…… [2]

[Total: 15]

4 Iron is a transition element in Period 4 of the Periodic Table.

(a) Explain what is meant by a transition element.

…… [1]

(b) Most iron oxide samples have a mole ratio of iron to oxygen in a range between 0.84 : 1 to 0.96 : 1. Suggest why these samples have variable compositions.

……

…… [1]

(c) The reaction between peroxodisulfate ions, $S_2O_8^{2-}$ and iodide ions is very slow at room conditions, while addition of iron(III) ions can speed up the reaction rate.

(i) Suggest why the reaction between $S_2O_8^{2-}$ and iodide ions is very slow.

……

…… [1]

(ii) Construct ionic equations to outline the catalytic role of iron(III) ions in the reaction.

……

…… [2]

(iii) State another iron species that can also act as a catalyst for the reaction.

…… [1]

(d) When thiocyanate ligand, SCN^-, is added to the yellow solution of $FeCl_3$, a deep red solution **H** is obtained.

(i) Suggest the formula of the complex responsible for the deep red solution **H**.

…… [1]

(ii) State the type of reaction when $FeCl_3$ forms **H**.

…… [1]

(iii) Explain why aqueous Fe^{3+} solutions are coloured.

……

……

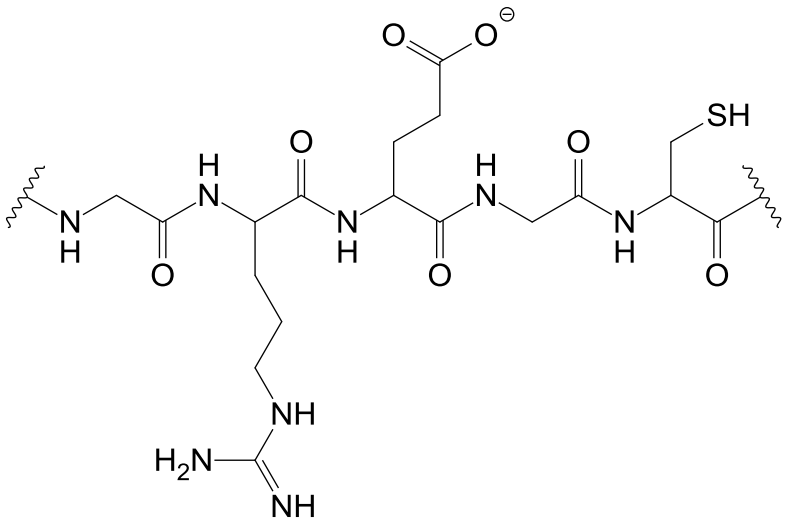
……

…… [3]

[Total: 11]

5 The pancreas produces the protein insulin that regulates the metabolism of carbohydrates, fats and proteins.

The structure of a portion of the insulin molecule is shown below. This portion contains a number of amino acids.



(a) Describe the tertiary structure of insulin.

.....

.....

..... [2]

(b) **(i)** What is meant by the term *denaturation*?

.....

..... [1]

(ii) Suggest a brief outline of one method by which insulin may be denatured.

.....

.....

.....

..... [2]

(iii) State the reagent and conditions required for complete hydrolysis of protein in the laboratory.

…… [1]

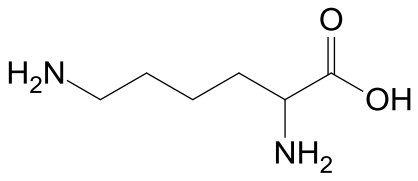
(iv) One of these amino acid residues are present more than once in the above portion of the insulin molecule. Draw a displayed formula for this amino acid residue.

[1]

(v) Explain, with the aid of equations, how the zwitterionic form of the amino acid in **(b)(iv)** act as a buffer.

…… [2]

(c) Lysine is a α-amino acid that is used in the biosynthesis of proteins.



(i) Explain what is meant by the term pK_a as applied to a weak acid H*A*.

……

…… [1]

(ii) State the functional groups present in lysine.

…… [1]

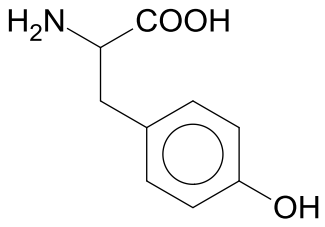
(iii) There are three pK_a values associated with lysine: 2.1, 8.9 and 10.5.

Make use of these pK_a values to suggest the major species present in the solutions of the amino acid with the following pH values.

pH 1	**pH 4**
pH 9	**pH 12**

[4]

(d) Tyrosine is another amino acid present in insulin.



Draw the organic products when tyrosine undergoes reaction with

(i) $Br_2(aq)$

[1]

(ii) NaOH(aq)

[1]

(iii) excess CH_3CH_2COCl

[1]

(e) State the type of reactions for **reaction with**.

$Br_2(aq)$ ……

NaOH(aq) …… [2]

[Total: 20]

END OF PAPER

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