Candidate Name: _____ **CT Group: 07S_____**

HWA CHONG INSTITUTION

C2 PRELIMINARY EXAMINATION

9746 H2 CHEMISTRY

Paper 2 Structured

16 September 2008 **1 hour 30 minutes**

Do not open this booklet until you are told to do so.

READ THESE INSTRUCTIONS FIRST

Write your name and class clearly in the spaces at the top of this page.

Write in dark blue or black pen.

You may use a soft pencil for any diagrams, graphs or rough working.

Answer **all** questions in the spaces provided in this question booklet.

A *Data Booklet* is provided.

You may use a calculator.

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

You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use	
1	/11
2	/5
3	/9
4	/15
5	/8
6	/12
Total	/60

Answer **all** the questions.

1 (a) The table below gives the melting points of some elements of Period 3.

Element	phosphorus	sulphur	chlorine
Melting point /K	317	392	172

In terms of structure and bonding, explain why sulphur has the highest melting point among the three elements.

.....

.....

.....

.....

[2]

(b) Sulphur dissolves in aqueous sodium hydroxide to form sodium thiosulphate, $Na_2S_2O_3$, and sodium sulphide, Na_2S.

(i) State the type of reaction taking place.

.....

(ii) Write ionic half-equations for the reaction and hence construct a balanced equation, including state symbols, for the reaction.

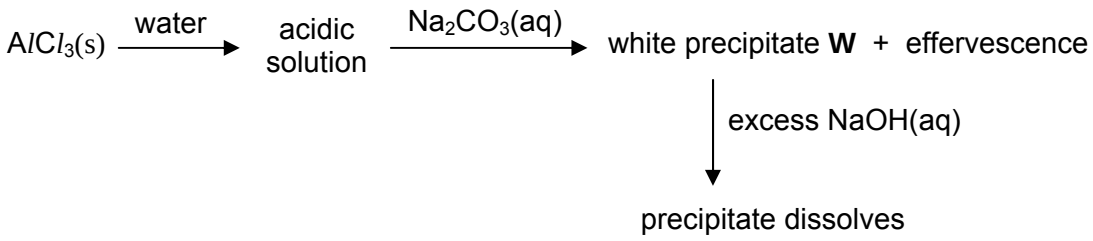
.....

.....

.....

[3]

(c) The following test-tube experiments are carried out starting from solid aluminium chloride.



(i) Explain with the help of a balanced equation, why $AlCl_3$(s) dissolves to form an acidic solution.

.....

.....

.....

.....

.....

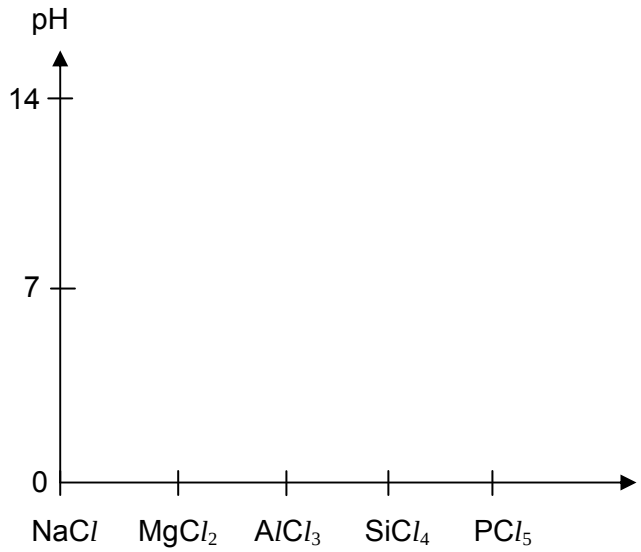
(ii) Identify **W**.

.....

(iii) Write a balanced equation, including state symbols, for the reaction of **W** with excess NaOH(aq).

.....

(iv) The chlorides of the elements, sodium to phosphorus, dissolve in or react with water. On the axes below, sketch the variation in pH of the solution obtained when each of these chlorides is dissolved in water.



[6]

[TOTAL: 11]

2 (a) Give an example of a reaction that uses a transition metal or its compound as a heterogeneous catalyst.

Equation for reaction: .....

Heterogeneous catalyst: .....

[2]

(b) With reference to your example in **(a)**, explain the mode of action of a heterogeneous catalyst.

.....

.....

.....

.....

.....

[2]

(c) In heterogeneous catalysis, the reactants must be carefully purified to prevent *poisoning of the catalyst*. Suggest what is meant by the terms in *italics*.

.....

.....

[1]

[TOTAL: 5]

3 (a) Meals-ready-to-eat (MRE) are military meals that can be heated on a flameless heater. The heat is produced by the following reaction :

$$Mg(s) + 2H_2O(l) \rightarrow Mg(OH)_2(s) + H_2(g)$$

(i) Use the data below to calculate the standard enthalpy change for this reaction.

Compound	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$H_2O(l)$	−286
$Mg(OH)_2(s)$	−925

(ii) A MRE pack contains 2.4 g of magnesium which comes in contact with 100 g of water upon breaking a valve. Using your answer in **(a)(i)**, determine whether this pack can be used to raise the temperature of the water from 25 ^{o}C to its boiling point.

Specific heat capacity of water = 4.2 J g^{-1} K^{-1}

[3]

(b) The following data relate to the energy changes which occur when sodium hydroxide, NaOH, and magnesium hydroxide, $Mg(OH)_2$, dissolve in water.

	sodium	magnesium
Hydration energy of metal ion / kJ mol^{-1}	−390	−1890
Lattice energy of metal hydroxide / kJ mol^{-1}	−896	−2995
Enthalpy change of solution of metal hydroxide / kJ mol^{-1}	−44	x
Extent of hydration of metal ion (Average number of attached water molecules per metal ion)	5	15

(i) Explain why the hydration energy of Mg^{2+} is more exothermic than that of Na^+.

.....

(ii) Use the data above to calculate x, the enthalpy change of solution of $Mg(OH)_2$.

(iii) Solubility is also controlled by the entropy change which accompanies dissolution. Use the extent of hydration from the table to compare qualitatively the entropy changes of solution of $Mg(OH)_2$ and NaOH.

.....

.....

.....

.....

(iv) Suggest and explain one other factor which contributes to the total entropy change when $Mg(OH)_2$ dissolves in water.

.....

.....

.....

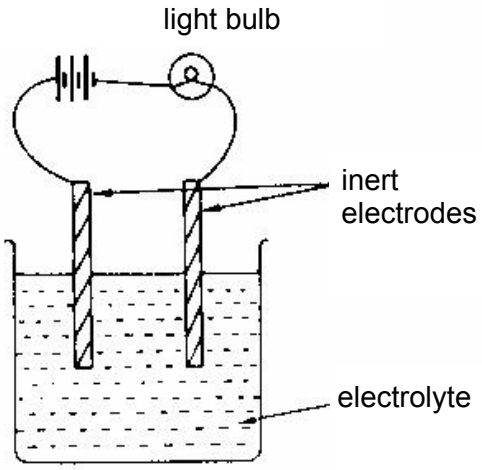
.....

[6]

[TOTAL: 9]

4 (a) The circuit in the diagram was set up. Using dilute ethanoic acid as the electrolyte, it was found that two gases, **A** and **B**, were liberated at the anode in a 2:1 ratio by volume.

Gas **A** forms a white precipitate with aqueous calcium hydroxide while gas **B** has composition by mass of 20% H and 80% C.



(i) Deduce the identity of gas **B**.

(ii) Construct the half-equation for the reaction at the anode.

.....

(iii) State **two** differences which would result if the electrolyte had been replaced with dilute sulphuric acid of the same concentration.

.....

.....

.....

.....

.....

[4]

(b) Group II hydroxides may exist as hydrates with the formula $\mathbf{M}(OH)_2 \cdot nH_2O$.

A 1.295 g sample of this hydroxide was heated with a loss of 0.590 g in the form of steam, as it was converted into the anhydrous hydroxide. Subsequent heating to constant mass produced the oxide with a further mass loss of 0.0740 g.

Determine n. Find the identity of the metal **M**.

[4]

(c) What is the minimum concentration of $\mathbf{M}(OH)_2(aq)$ required if 5.0 cm^3 of this solution is added to 100 cm^3 of 0.010 mol dm^{-3} H_2SO_4, for a precipitate to be observed?.

[K_{sp} (MSO_4) = 1.30×10^{-10} $mol^2\ dm^{-6}$]

[2]

(d) Sodium pyruvate is an important chemical in biochemistry. It is the product of the anaerobic metabolism of glucose. Its acid, pyruvic acid, CH_3COCO_2H, can be prepared from ethanoic acid using the following reaction scheme.

$$CH_3CO_2H \xrightarrow{\mathbf{I}} CH_3COBr \xrightarrow{KCN} \mathbf{X} \xrightarrow{\mathbf{II}} \underset{\text{pyruvic acid}}{CH_3COCO_2H}$$

(i) Give reagents and conditions for steps **I** and **II**.

Step **I** : .....

Step **II** : .....

(ii) Draw the structure of compound **X**.

(iii) Name the mechanism for the reaction of CH_3COBr with KCN to form **X**.

.....

(iv) Pyruvic acid can be reduced to lactic acid, $CH_3CH(OH)CO_2H$.

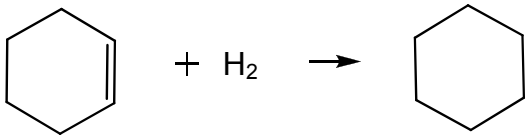
Give the reagents and conditions for this reaction.

.....

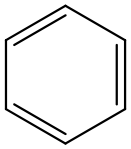
[5]

[TOTAL: 15]

5 (a) (i) By using relevant data from the *Data Booklet*, calculate the enthalpy change for the hydrogenation of cyclohexene.



(ii) In 1865, Friedrich Kekule described benzene as a ring of alternating single and double bonds:



From experimental determination, the enthalpy change of hydrogenation of benzene was found to be -205 kJ mol^{-1}.

Explain, in terms of the structure of benzene, why this value is not three times your answer in **(a)(i)**. Use an energy level diagram to illustrate your answer.

.....

.....

.....

[3]

(b) Nitrobenzene is prepared by reacting benzene with a nitrating mixture.

(i) Describe the mechanism for the formation of nitrobenzene from benzene.

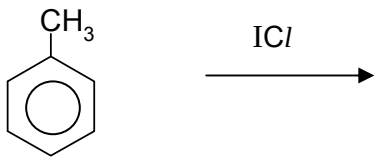
(ii) During the nitration reaction, a di-substituted product is also formed.

Draw the likely structure of this product.

[4]

(c) Iodine monochloride, IC*l*, can be prepared by passing chlorine gas over iodine crystals and it is collected as a dark brown liquid.

Draw the structure of the likely organic product of the reaction of IC*l* with methylbenzene in the box below.



[1]

[TOTAL: 8]

6 The pancreas secretes pancreatic juice which contains a digestive enzyme **A**. Enzyme **A** is a protein molecule that catalyses the breaking down of food in the intestines.

(a) In the study of the polypeptide structure of **A**, it was digested using two different enzymes. The fragments obtained were separated using electrophoresis. Analysis of the fragments from each digestion gave the following results:

Digestion using the first enzyme:

gly-pro-val
ser-pro-glu
asp-gly
thr-phe-leu

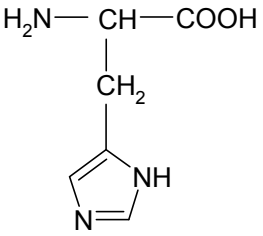
Digestion using the second enzyme:

val-asp-gly-thr
pro-glu
phe-leu-ser
gly-pro

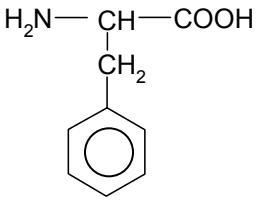
(i) Deduce the primary structure of **A**.

.....

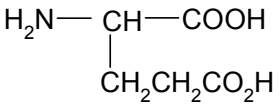
(ii) A tripeptide, his-phe-glu, obtained from **A** was further hydrolysed. The resulting solution was added to an excess of a buffer solution of pH 6.5 and placed at the centre of the plate. A potential difference was then applied across the plate.



his



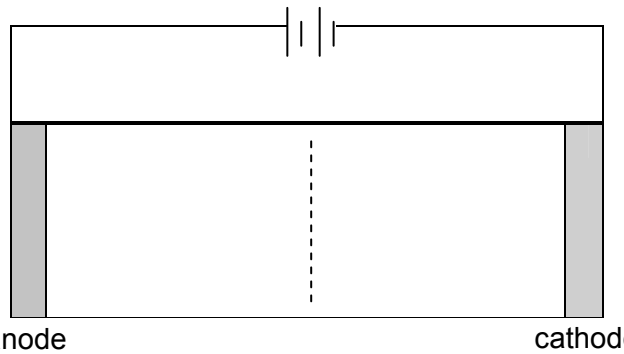
phe



glu

	his	phe	glu
Isoelectric point :	7.58	5.48	3.10

Indicate the relative positions of the amino acids on the diagram below.



anode cathode **[4]**

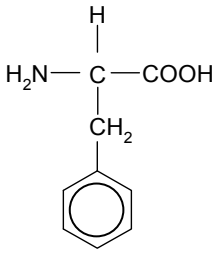
(b) The functions of enzyme **A** is affected when the *tertiary structure* of the protein changes.

(i) Define the term *tertiary structure of a protein*.

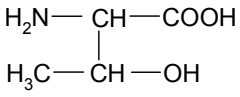
.....

.....

(ii) In a person suffering from a disease that causes diminished secretion of pancreatic enzymes, it is found that enzyme **A** has the amino acid, threonine, instead of phenylalanine. These two amino acids are shown below.



phenylalanine (phe)



threonine (thr)

Suggest how the difference in structure of the two amino acids might affect the tertiary structure of the enzyme, and why this might prevent the enzyme from working.

.....

.....

.....

.....

[3]

(c) Amino acids exhibit isomerism.

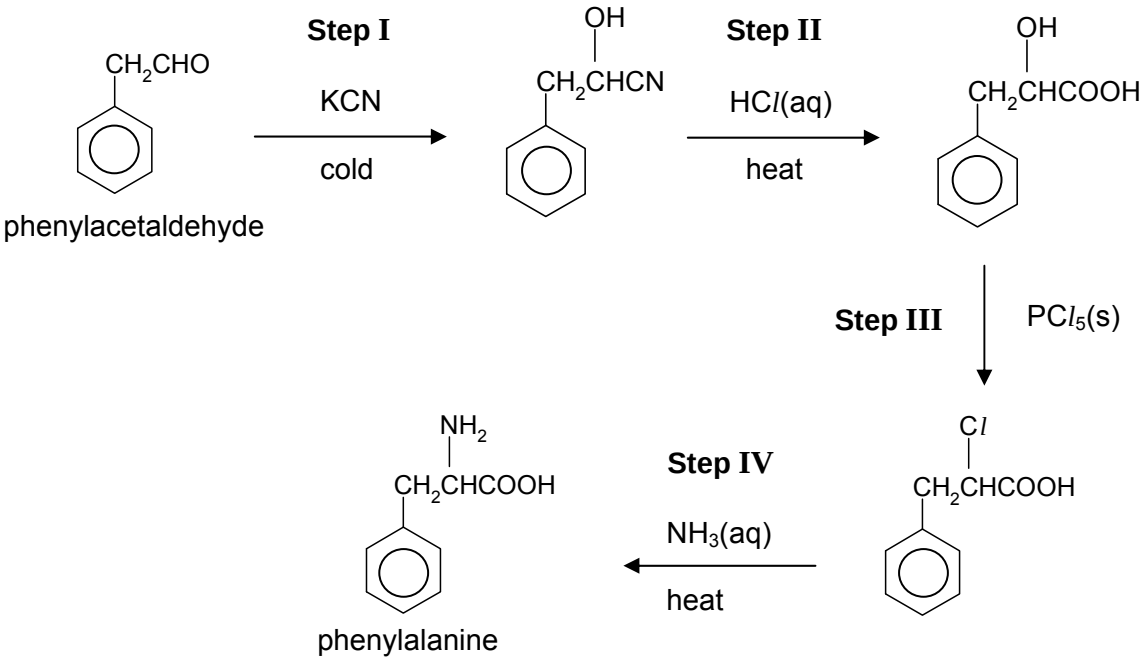
(i) What type of isomerism can be shown by phenylalanine?

.....

(ii) Draw the isomers that phenylalanine forms.

[2]

(d) The following method was proposed by a student to synthesise phenylalanine from phenylacetaldehyde for his research project.



His mentor commented that there are some errors in his method. Identify and explain the three errors present in his choice of reagents. (*You may consider the steps in isolation.*)

Step	Error

[3]

[TOTAL: 12]

– End of Paper–