HWA CHONG INSTITUTION
C2 Preliminary Examinations
Higher 2

CANDIDATE NAME		**CT GROUP**	**12S**
CENTRE NUMBER		**INDEX NUMBER**	

CHEMISTRY

9647/02

Paper 2 Structured Questions

18 September 2013

2 hours

Candidates answer on the Question Paper

Additional Materials: Data Booklet

INSTRUCTIONS TO CANDIDATES

1) Write your **name**, **CT group, centre number** and **index number** clearly in the spaces at the top of this page.

2) Answer **all** questions in the spaces provided in this Question Paper.

INFORMATION FOR CANDIDATES

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

A Data Booklet is provided.

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

You may use a calculator.

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

For Examiner's Use	
1	**/ 12**
2	**/ 20**
3	**/ 13**
4	**/ 12**
5	**/ 15**
Total	**/ 72**

Calculator Model:

1 Planning

You are provided with a 2.00 mol dm^{-3} solution of sodium hydroxide and a solution of sulfuric acid of unknown concentration.

The enthalpy change of neutralization, ΔH_{neut}, is the molar enthalpy change for the reaction:

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$$

A preliminary investigation was carried out to measure the temperature changes, ΔT, when different volumes of the sulfuric acid and sodium hydroxide were reacted together.

In one experiment, 10.00 cm^3 of H_2SO_4 was reacted with 40.00 cm^3 of NaOH and the temperature change was found to be 11.0 ^oC.

In a second experiment, 20.00 cm^3 of H_2SO_4 was reacted with 30.00 cm^3 of NaOH and the temperature change was 18.4 ^oC.

(a) Write a plan to determine the concentration of the sulfuric acid, and a value for the enthalpy change of neutralization, ΔH_{neut}. Your plan must enable you to plot a graph that includes the data from both of the experiments described above. You may use apparatus normally found in a school laboratory.

Your plan should contain the following:

- a labelled diagram of the assembled apparatus you would use for measuring the temperature changes, ΔT,
- all essential experimental details, including precision of apparatus and volumes of reagents,
- a sketch of the graph you expect to obtain, and
- an outline of the calculations you would perform to find

(i) the concentration, **in mol dm^{-3}**, of the sulfuric acid
(ii) the molar enthalpy change of neutralization, ΔH_{neut}, **in kJ mol^{-1}**

In your calculations, you must clearly define all terms used and simplify your final mathematical expression.

You may use letters ***a, b,*** … etc, to represent quantities used.

For Examiners Use

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[10]

(b) A student carries out your plan using 1.00 mol dm^{-3} barium hydroxide instead of 2.00 mol dm^{-3} sodium hydroxide. Explain whether he would obtain the same results for the concentration of sulfuric acid and for the molar enthalpy change of neutralization, within experimental errors.

For Examiners Use

11	
12	

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[2]

[Total: 12]

2 **(a)** A pink complex salt **A** has the molecular formula $CoN_5H_{17}OCl_3$ (M_r = 268.4).

1.00 g of **A** is dissolved in water and the solution is titrated with 0.500 mol dm^{-3} silver nitrate solution. It is found that 22.40 cm^3 of silver nitrate is required for complete reaction.

When the pink solid **A** is heated, water vapour was evolved to give a purple solid **B**.

A and **B** have the same coordination number.

(i) Calculate the number of moles of free chloride ions per mole of **A**.

(ii) Draw the structure of the complex ion in **A.**

(iii) Suggest the formula of the complex ion in **B**.

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(iv) Account for the difference in the colour of **A** and **B**.

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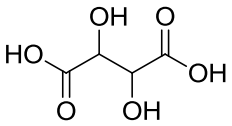
[5]

(b) Aqueous hydrogen peroxide is fairly stable, but when a mixture of a cobalt(II) salt and tartaric acid is added to aqueous hydrogen peroxide, the *initially pink solution slowly turns into a green Co(III) species*.



tartaric acid

After a while, *oxygen gas is vigorously evolved and the solution turns back to pink again*. Both tartaric acid and the cobalt(II) salt are recovered from the solution at the end.

(i) Explain the reactions that occurred in the observations that are in *italics*.

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(ii) State the role of the cobalt(II) salt and give two pieces of evidence to support your answer.

Role of the cobalt(II) salt: ……

Evidence 1:

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Evidence 2:

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(iii) Write an equation for the overall reaction.

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(iv) With the aid of relevant data in the *Data Booklet*, show that Co^{3+} is not stable in aqueous solution and hence comment on the role of tartaric acid.

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[9]

(c) A student wants to plate a leaf with a thin layer of cobalt. He first coated the leaf with graphite. The leaf and a platinum electrode were then immersed into an aqueous solution of cobalt(II) sulfate and electroplating was carried out.

(i) Draw a fully labelled sketch of the electroplating set-up.

(ii) Give the equations, with state symbols, for the processes occurring at the anode and cathode.

Cathode: …….....

Anode : …….....

(iii) After some time, the leaf was coated with a 0.20 mm layer of cobalt. Given that the surface area of the leaf was 10 cm^2 and the density of cobalt metal is 8.90 g cm^{-3}, calculate the volume of gas produced at the platinum electrode at room temperature.

(iv) Calculate the time taken, in hours, to coat the leaf in **(iii)** if the current used was 0.5 A.

[6]
[Total: 20]

3 (a) In fast nuclear reactors, the nuclear fission chain reaction is sustained by fast neutrons. They typically operate at a temperature of about 600 ^{o}C and so water is unsuitable as a cooling liquid. Instead, liquid metals are used as the cooling agents.

The melting and boiling points of some metals are given in the table below.

Metal	Melting point /^{o}C	Boiling point /^{o}C
Magnesium	650	1090
Sodium	98	884
Mercury	–39	357

(i) From the list of metals, select one metal that can be used as a cooling agent for the nuclear reactor. Explain your choice.

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(ii) Explain why the melting point of magnesium is higher than that of sodium.

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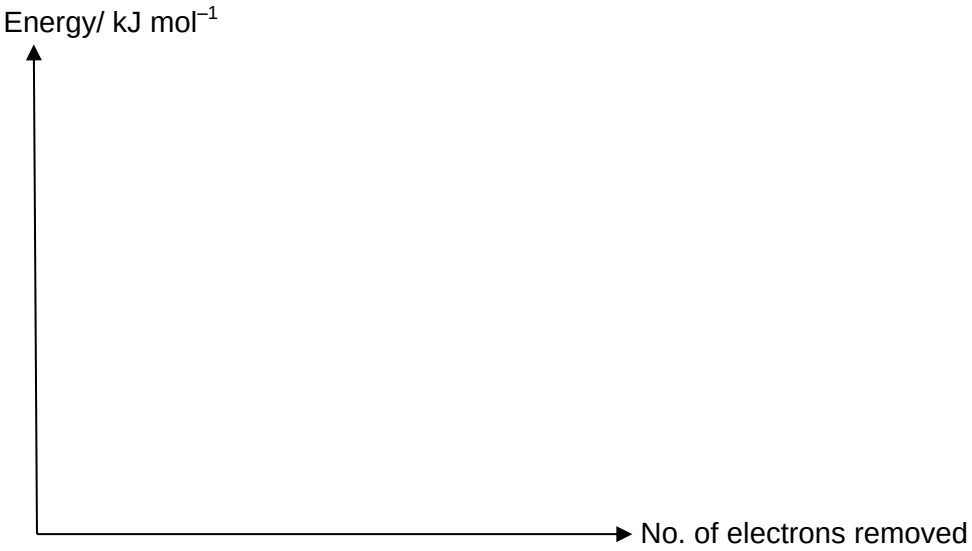
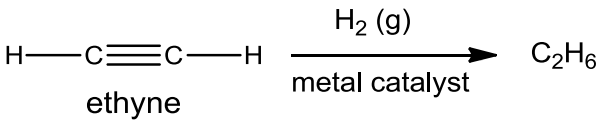
(iii) On the axis provided, sketch the first ten successive ionization energies of the magnesium atom.



[4]

9

(b) Alkynes are highly versatile compounds that may be utilized for numerous reactions. They can be easily reduced to their alkanes by addition of H_2 over a metal catalyst.



(i) With the aid of the Maxwell Boltzmann distribution curve, explain why the addition of a catalyst will increase the rate of reaction.

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(ii) Describe, in terms of orbital overlap, the bonding of the two carbon atoms of the C%C bond in ethyne. You may use diagrams to illustrate your answer.

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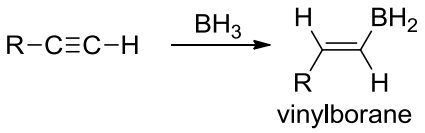
[5]

10

(c) Alkynes can form vinylborane through a process known as hydroboration.

This process can be viewed as an electrophilic addition reaction with borane, BH_3, as the attacking electrophile.



vinylborane

(i) Explain why BH_3 can behave as an electrophile to form vinylborane.

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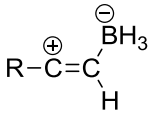
(ii) It is suggested that the electrophilic addition of alkynes by BH_3 goes through the formation of the intermediate below.

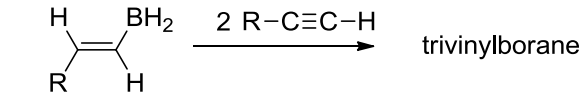


Describe the reaction mechanism for the formation of vinylborane.

11

(iii) The addition of BH_3 across the C%C bond forms only the *trans* isomer of vinylborane.

The *trans*-vinylborane then undergoes multiple additions to form trivinylborane.



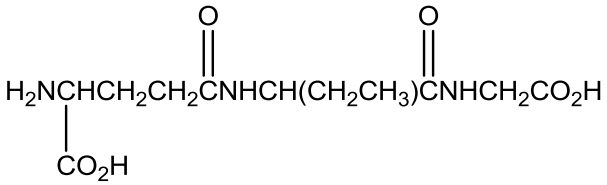
trans-vinylborane

One mole of trivinylborane reacts with 3 moles of Br_2 in CCl_4.

Suggest the structure of trivinylborane.

[4]
[Total: 13]

4 **(a)** Ophthalmic acid, a tri-peptide, is an antioxidant used to prevent damage to important cellular components caused by reactive oxygen species such as free radicals and peroxides.



ophthalmic acid

(i) What is unusual about the peptide bond formed by the N-terminal amino acid in ophthalmic acid?

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(ii) Draw the structural formulae of the compounds formed when ophthalmic acid undergoes complete acid hydrolysis.

[4]

(b) To understand patients suffering from knee joint rheumatoid arthritis, scientists often study the amino acid sequence of the cartilage protein isolated from their knees.

A segment of the polypeptide structure of cartilage protein, containing 11 amino acids, was digested using an enzyme and the following fragments were identified.

Leu – Pro – Val – Lys – Val
Ile – His – Cys – Pro – Gly
Cys – Pro – Gly – Val – Leu – Pro

State the primary structure of this segment of cartilage protein.

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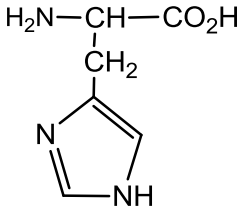
[1]

(c) Histidine, one of the amino acids found in cartilage protein, has the following structure.



histidine

(i) Explain how low pH might affect the tertiary structure of the cartilage protein.

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(ii) Explain why histidine is soluble in water.

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A sample of histidine extracted from cartilage protein rotated plane polarised light anticlockwise.

A second sample of histidine obtained from laboratory synthesis had no effect on plane polarised light.

(iii) Suggest an explanation for these observations.

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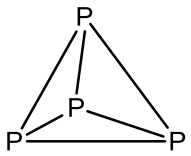
(iv) Draw structures to show the optical isomers of histidine.

[7]
[Total: 12]

5 The structure of white phosphorus is given below.



white phosphorus

(a) **(i)** Using the structure above, explain why white phosphorus is highly reactive and unstable.

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(ii) Write an equation to illustrate the reaction of white phosphorus with excess oxygen to give phosphorus oxide. Include state symbols in your equation.

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[2]

(b) Phosphoric(V) acid may be produced by the "thermal" process. The phosphoric(V) acid produced is essentially free from impurities and is used in food products. The acid is made by burning a spray of molten phosphorus in a mixture of air and steam in a stainless steel combustion chamber.

(i) Write an equation, including state symbols, to represent the conversion of phosphorus to phosphoric acid using the 'thermal' process.

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(ii) Highly diluted phosphoric(V) acid is used in soft drinks to impart a sour taste.

A 500 cm^3 bottle of Coca Cola usually contains a 0.05% solution by mass of phosphoric(V) acid. Assuming that the density of the drink is 1 g cm^{-3} and taking phosphoric(V) acid to behave as a monoprotic acid, calculate the pH of the drink.

[K_{a_1} (H_3PO_4) = 7.5 $\times 10^{-3}$ mol dm^{-3}; M_r (H_3PO_4) = 98.0]

[4]

(c) The kinetic theory of gases was stated by Emil Clapeyron in 1834. Gaseous PCl_5 is considered a non-ideal gas. Explain **three** ways in which gaseous PCl_5 violates the ideal gas assumptions.

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[3]

(d) A hydrocarbon, C_4H_{10}, was irradiated with *uv* light in the presence of a limited amount of chlorine gas to give **C** and **D**, both of which do not rotate plane-polarised light. On further treatment with hot concentrated alcoholic potassium hydroxide, both **C** and **D** gave **E**.

(i) Draw the structures of **C**, **D** and **E**.

C:	**D**:	**E**:

Further investigation showed that in addition to compound **E**, minute amounts of a side product **F**, $C_8H_{18}O$, was found in the product mixture after the treatment with hot concentrated alcoholic potassium hydroxide.

(ii) Suggest how compound **F** may have been produced.

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(iii) Suggest the structure of compound **F**.

[6]
[Total = 15]