CANDIDATE'S NAME: _____ CTG: _____

YISHUN JUNIOR COLLEGE
PRELIMINARY EXAMINATION

CHEMISTRY **8872/02**

Higher 1

2 hours

Paper 2

Additional materials: Answer Paper

Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your Name and CTG on cover page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for diagrams, graphs or rough working.
Do not use staples, paper clips, hightlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **two** questions on separate answer paper.

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.

For Examiner's Use	
Section A	
1	**/14**
2	**/7**
3	**/8**
4	**/11**
Sub-total	**/40**
Section B	
Sub-total	**/40**
Total	**/80**

Section A

Answer **all** the questions in this section in the spaces provided.

1 Sir James Jeans, who was a great populariser of science, once described an atom of carbon as being like six bees buzzing round a space the size of a football stadium.

(a) (i) Suggest what were represented by the six bees in this description.

.....

(ii) Explain (in terms of an atom of carbon) what stopped the bees from flying away from the space of the football stadium.

.....

.....

.....

(iii) What is missing from Jeans' description when applied to an atom of carbon?

.....

.....

[3]

(b) A sample of oxygen consisting mainly of the isotope oxygen-16 was enriched with oxygen-18. The oxygen sample reacted with sodium as follows:

$$4Na\ (s) + O_2\ (g) \rightarrow 2Na_2O\ (s)$$

(i) Complete the table below to show the composition of some of the species involved in the reaction

species	protons	neutrons	electrons
$^{23}_{11}Na$			
$^{16}_{8}O$			
$^{18}_{8}O^{2-}$			

(ii) Write an equation for sodium oxide reacting with nitric acid.

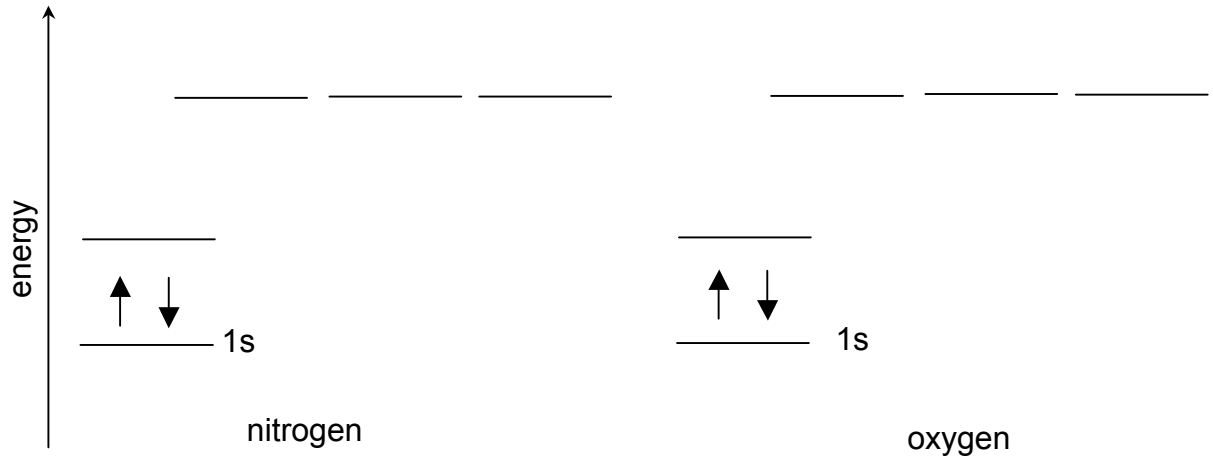
.....

(iii) The relative atomic mass of the oxygen sample is 16.5. Calculate the relative abundance of the two oxygen isotopes.

[5]

(c) Nitrogen and oxygen are found in the second period of the Period Table.

(i) Complete the electron configurations of nitrogen and oxygen on the energy level diagrams below, using arrows to represent electrons.



(ii) Explain, with reference to your answer to **(c)(i)**, the relative values of the first ionisation energies of nitrogen and oxygen. The values are given in the *Data Booklet* and should be quoted in your answer.

.....

.....

.....

.....

(iii) State the formula of the negatively charged ion formed by nitrogen in simple binary compounds.

.....

(iv) Why do nitrogen and oxygen form negative ions but not positive ions, in simple binary compounds?

.....

.....

.....

[6]

[Total: 14]

2 This question is about hydrogen peroxide, H_2O_2, and its decomposition.

(a) **(i)** Draw a "dot and cross" diagram to show the electronic structure for hydrogen peroxide, showing outer electrons only.

(ii) State the shape and O–O–H bond angle.

.....

[2]

(b) Hydrogen peroxide is a liquid at room temperature. With an aid of a diagram, identify and show the intermolecular force between hydrogen peroxide molecules.

[1]

(c) Hydrogen peroxide decomposes slowly at room temperature.

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

Explain, using oxidation numbers, why this is a disproportionation reaction.

.....

.....

[1]

(d) The oxidation number of vanadium in a complex ion was determined as follows.

2.08 x 10^{-3} mol sample of the complex was dissolved in water and the solution made up to 100 cm^3.

A 25.0 cm^3 portion of this solution required 5.20 x 10^{-4} mol of H_2O_2 to oxidise all the vanadium to the +5 oxidation state. Given the reaction H_2O_2 undergoes is $H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$, calculate

(i) the number of moles of vanadium complex in 25.0 cm^3 portion.

(ii) the original oxidation number of the vanadium in the complex.

[3]
[Total: 7]

3 (a) (i) In the boxes below, write the formulae of **one** of the chlorides of each of these four elements and the pH of its aqueous solutions.

	sodium	magnesium	aluminium	phosphorus
formula				
pH				

(ii) Write an equation to justify the pH you have written in **(a)(i)** for the aqueous solution of the chloride of phosphorus.

.....

(b) The lattice energy of sodium chloride is 769 kJ mol^{-1}. How you would expect the lattice energy of magnesium oxide to differ from that of sodium chloride? Explain your answer.

.....

.....

.....

[5]

(c) Aluminium fluoride and aluminium chloride each sublimes when heated. The former has a sublimation point of 1270^{o}C whereas the latter's sublimation point is 178^{o}C.

(i) Use these data to suggest the nature of the bonding in both aluminium halides, explaining your answer.

.....

.....

.....

.....

(ii) Aluminium chloride can react with ammonia in a molar ratio of 1:1 to form a product **X**. Give the full structural formula for **X**, showing clearly the type of bonds present.

[3]
[Total: 8]

4 A student obtained the following results when analysing an organic compound, **A**.

test		observation
test 1	relative molecular mass	86
test 2	% composition by mass	C, 69.8%; H, 11.6%; O, 18.6%
test 3	reactions with Br_2 in CCl_4	Br_2 decolourised
test 4	reaction with Na	H_2 (g) evolved
test 5	reaction with warm alkaline I_2 (aq)	pale yellow precipitate formed

(a) Calculate the molecular formula of **A**.

[2]

(b) What can be deduced about the nature of **A** by the following tests?

(i) test 3

.....

(ii) test 4

.....

(iii) test 5

.....

[3]

The student reacted **A** with hot acidified $K_2Cr_2O_7$ (aq) and then investigated the product, **B**, with the following results.

test		observation
test 6	reaction with 2,4-dinitrophenylhydrazine	positive observation
test 7	reaction with Fehling's reagents	no reaction

(c) **(i)** State what you would see when **B** reacts with the 2,4-dinitrophenylhydrazine reagent.

.....

(ii) What functional group is shown to be present in **A** by tests 5, 6 and 7?

.....

[2]

(d) On testing samples of **A** and **B**, the student found that both show cis-trans isomerism.
How does cis-trans isomerism arise in an organic molecule?

.....

.....

.....

[2]

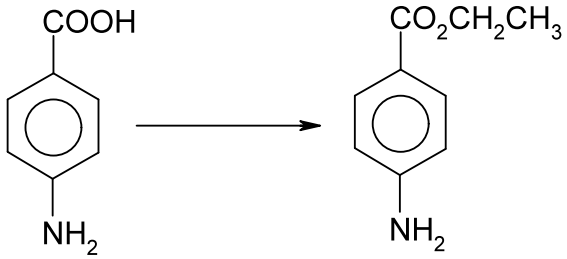
(e) Use all of the information above to draw labelled, displayed formulae of the stereoisomers of compound **A**.

[2]
[Total: 11]

Section B

Answer **two** of the three questions in this section on separate paper.

5 This question is about benzocaine, a topical anaesthetic used in first aid creams and sunburn remedies. It can be produced by refluxing para-amino benzoic acid, PABA with ethanol and concentrated sulfuric acid.



PABA benzocaine

(a) Write a balanced equation for this reaction. [1]

(b) A series of experiments were carried out to investigate the kinetics of the reaction in **(a)**. The following results were obtained.

Experiment	Initial concentration of reactant			Initial rate of formation of benzocaine, mol dm^{-3} s^{-1}
	PABA, mol dm^{-3}	ethanol, mol dm^{-3}	sulfuric acid, mol dm^{-3}	
1	0.010	0.010	0.010	2.0×10^{-6}
2	0.030	0.010	0.010	6.0×10^{-6}
3	0.030	0.020	0.010	1.2×10^{-5}
4	0.030	0.020	0.020	1.2×10^{-5}

Use the data given in the table above to find the

(i) rate equation

(ii) rate constant, stating its units

[6]

(c) With the aid of a sketch of the *Boltzmann distribution*, state and explain the effect of an increase in temperature on the rate of a chemical reaction. [4]

(d) 100 cm^3 of 0.500 mol dm^{-3} benzocaine was mixed with 100 cm^3 of 0.250 mol dm^{-3} sodium hydroxide and the increase in temperature was 13.4°C. Both solutions were initially at room temperature. Assume specific heat capacity of all solution to be 4.2 J g^{-1} K^{-1} and all solutions have a density of 1.0 g cm^{-3}, calculate

(i) heat evolved from the reaction

(ii) the enthalpy change of reaction. [3]

(e) **(i)** PABA is a monobasic acid and can be denoted as HX. Its K_a = 1.5 x 10^{-5} mol dm^{-3}. Write an expression for the acid dissociation constant, K_a, and determine the pH of a 0.10 mol dm^{-3} solution of PABA.

(ii) Explain what is meant by the term buffer solution. With the aid of equations, describe how aqueous PABA (HX) and sodium para-aminobenzoate (NaX) work as a buffer.

[6]

[Total: 20]

6 Ethanol, C_2H_5OH, is an important industrial chemical. It is used as a solvent, a fuel and an intermediate in large scale organic synthesis.

Ethanol is prepared industrially by the reaction of ethene and steam in the presence of a catalyst.

$$C_2H_4\ (g)\ +\ H_2O\ (g)\ \rightarrow\ C_2H_5OH\ (g)$$

The standard enthalpy change of the reaction can be determined by using the standard enthalpy changes of combustion, $\Delta H_c^{\ominus}$, at 298 K.

	$\Delta H_c^{\ominus}$/ kJ mol^{-1}
C_2H_4 (g)	- 1411
C_2H_5OH (l)	- 1367

(a) **(i)** Using ethanol as an example, define standard enthalpy change of combustion.

(ii) Use the $\Delta H_c^{\ominus}$ given above, calculate the standard enthalpy change for the following reaction.

$$C_2H_4\ (g)\ +\ H_2O\ (l)\ \rightarrow\ C_2H_5OH\ (l)$$

(iii) Explain why the state symbols for water and ethanol given in equation in **(a)(ii)** have been changed from these quoted in the industrial process.

[4]

(b) Equal amounts of ethanol and ethanoic acid were mixed and allowed to reach equilibrium at room temperature. 60% of the acid was found to have reacted.

(i) Draw a sketch graph showing how the rates of the forward and reverse reactions change from the time ethanol and ethanoic acid was mixed to the time the reaction reaches equilibrium. Label your two lines clearly.

(ii) Calculate the equilibrium constant, K_c, for the reaction between ethanol and ethanoic acid.

(iii) What would be the effect(s), if any, of adding concentrated sulfuric acid to the reaction mixture?

[7]

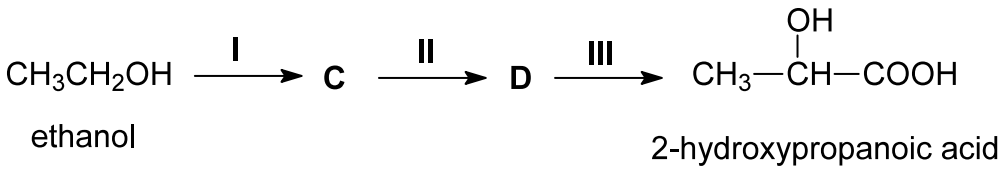
(c) Ethanol can be converted to chloroethane, which is a useful intermediate for making other organic compounds.

(i) Suggest the reagents and conditions for the conversion.

(ii) Describe one chemical test-tube reaction you could carry out to distinguish chloroethane from iodoethane.

[4]

(d) The reaction scheme below shows the synthesis of 2-hydroxypropanoic acid from ethanol.



ethanol

2-hydroxypropanoic acid

(i) Give the structures of **C** and **D**.

(ii) Suggest the reagents and conditions for reactions **I**, **II** and **III**.

[5]

[Total: 20]

7 **(a)** Compound **E** with molecular formula C_9H_{10} is found to decolourise brown bromine solution. Reaction of **E** with hot acidified potassium managante(VII) produces **F,** C_8H_8O and a gas that forms a white precipitate with calcium hydroxide solution. Compound **F** reacts with 2,4-dinitrophenylhydrazine to form a orange precipitate and is reduced by lithium aluminum hydride to form **G,** $C_8H_{10}O$. Both **F** and **G** react with aqueous alkaline iodine to form a yellow precipitate but only **G** reacts with phosphorous pentachloride to give out white fumes and compound **H**, C_8H_9Cl .

Suggest a possible structure for each of the compounds **E** to **H**. Explain the chemistry of the reactions described by writing balanced equations where appropriate.

[8]

(b) This part is about acid and base reaction.

(i) What are acids and bases according to BrØnsted-Lowry theory?

(ii) Find the pH of 0.100 mol dm^{-3} of aqueous sulfuric acid, H_2SO_4.

(iii) 25.0 cm^3 of 1.00 mol dm^{-3} sodium hydroxide was added to 50.0 cm^3 of 0.500 mol dm^{-3} hydrochloric acid. Given that the enthalpy change of neutralisation is -126 kJ mol^{-1} and the amount of heat energy required to raise the temperature of 1 cm^3 of solution by 1 K is 4.20 J. Calculate the final temperature of the solution, assuming that both solutions were initially at 25ºC.

(iv) Draw an energy profile of the reaction in **(b)(iii)**, showing clearly the activation energy and the enthalpy change of the reaction.

(v) Using the same energy profile diagram drawn in **(b)(iv)**, draw the energy profile of the reaction when a catalyst is added.

[10]

(c) Arrange the following compounds in order of increasing acid strength.

Explain your answer.

$CHCl_2COOH$, CCl_3COOH and $CH_2ClCOOH$

[2]

[Total: 20]