Candidate Name: _____

Class	Adm No

H

millennia institute

2013 Promotional Examination II
Pre-university 2

H1 CHEMISTRY 8872 / 02
Paper 2 Structured Questions

18 September 2013 (WEDNESDAY)

Candidates answer Section A on the Question Paper.

2 hours

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

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

Write your name, index number and class on all the work you hand in.
Write in dark blue or black pen on both sides of the writing paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluids.

Section A
Answer **all** questions.

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

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

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

At the end of the examination, arrange your answers in numerical order and fasten all your work securely together.

FOR EXAMINER'S USE	
SECTION A	
Q1	**/ 9**
Q2	**/ 11**
Q3	**/ 10**
Q4	**/ 10**
SECTION B	
Q__	**/ 20**
Q__	**/ 20**
Total	**/ 80**

This question paper consists of 13 printed pages and 1 BLANK PAGE.

[Turn over

SECTION A

Answer **all** questions in the space provided.

For Examiner's Use

1. **(a)** Draw a dot-and-cross diagram to illustrate the bonding in H_3S^+ and predict its shape.

[2]

(b) The bond angle of H_3O^+ is larger compared to that of H_3S^+. Explain.

_____

_____

_____

[2]

(c) Acids dissociate in water to give H_3O^+.

A solution of sulfuric acid was prepared by adding 500 cm^3 of water to a 25.0 cm^3 solution of 2.5 mol dm^{-3} of sulfuric acid.

(i) Calculate the concentration of the sulfuric acid solution formed.

(ii) Hence calculate the pH of the solution formed.

[3]

For Examiner's Use

1. (d) In a titration, a solution of aqueous NH_3 was titrated against the sulfuric acid solution prepared in **(c)**. Predict if the pH at the equivalence point would be equal to, more than or less than 7. Give an equation to support your answer.

pH: _____

Equation: _____

[2]

[Total: 9]

2. The term halogen, coined by a Swedish chemist Baron Jons Jakob Berzelius, refers to Group VII elements.

(a) Bromine, a halogen, reacts with hot aqueous KOH according to the equation below.

$$3Br_2(g) + 6KOH(aq) \rightarrow 5KBr(aq) + KBrO_3(aq) + 3H_2O(l)$$

(i) What are the oxidation states of bromine in the three bromine-containing compounds in the reaction?

Br_2: _____ KBr: _____ $KBrO_3$: _____

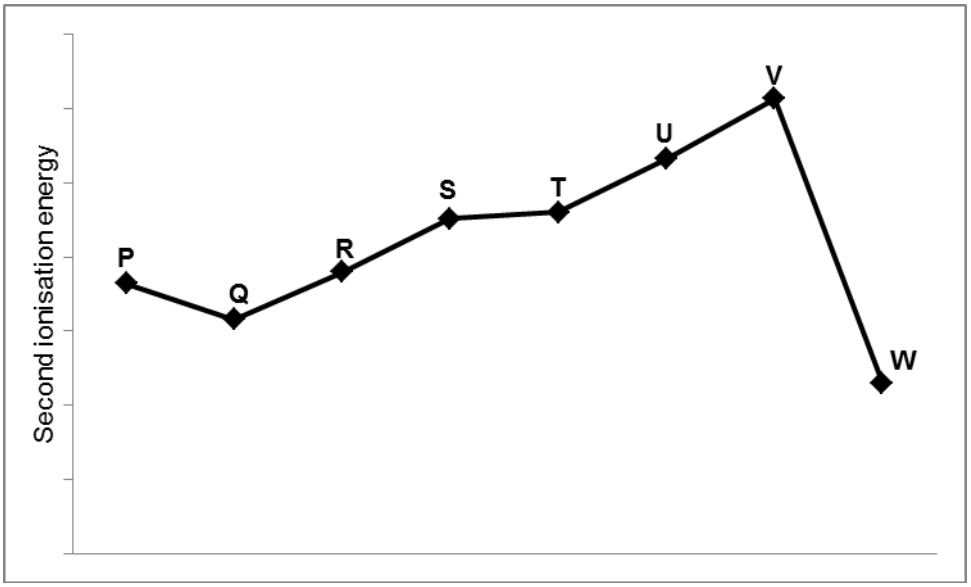
(ii) Hence state the type of reaction that has occurred.

_____

[2]

For Examiner's Use

2. (b) The diagram below shows the second ionisation energy of eight consecutive elements, **P** to **W,** in the Periodic Table. Their atomic numbers lie between 3 and 20.



(i) Which element represents a halogen?

_____

(ii) Explain the general increasing trend in second ionisation energies from elements **Q** to **V**.

_____

_____

_____

(ii) Predict, with reasons, the trend of second ionisation energies down Group VII.

_____

_____

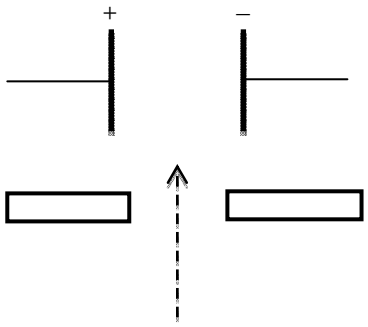
_____

[6]

For Examiner's Use

2. (c) In an experiment, a sample of ^{80}Br was vapourised and passed through an electric field. Analysis of the deflection occurring in the electric field revealed that a beam of $^{80}Br^-$ gave an angle of deflection of 1.05°.

On the diagram below, sketch how beams of gaseous $^{19}F^-$ and gaseous $^{56}Fe^{2+}$ will travel in the electric field. Indicate the angle of deflection clearly in your sketch.



[3]

[Total: 11]

For Examiner's Use

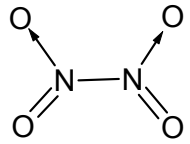
3. At room temperature, brown nitrogen dioxide and colourless dinitrogen tetraoxide are in dynamic equilibrium according to the following equation:

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

(a) Predict, with reasoning, how the position of equilibrium might change if the pressure is decreased.

[2]

(b) The Lewis structure of N_2O_4 is shown below.



Using bond energy data from the *Data Booklet*, calculate the enthalpy change for the reaction

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

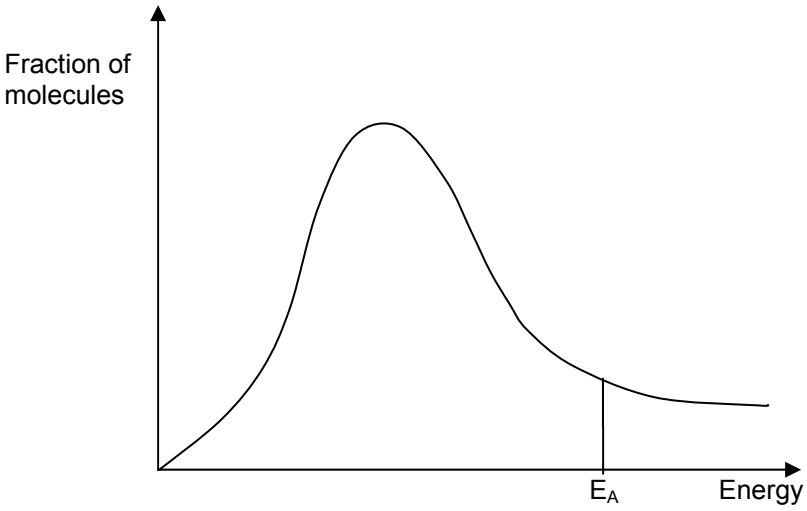
[1]

(c) Hence predict what would happen to the colour of the system when heat is applied to the equilibrium system. Explain your answer.

[3]

For Examiner's Use

3. (d) (i) The diagram below shows the Boltzmann distribution curve for the reaction at 298K. On the same diagram sketch the distribution curve for the same reaction carried out at 278K.



(d) (ii) Explain how a lower temperature affects the rate of reaction.

_____

_____

_____

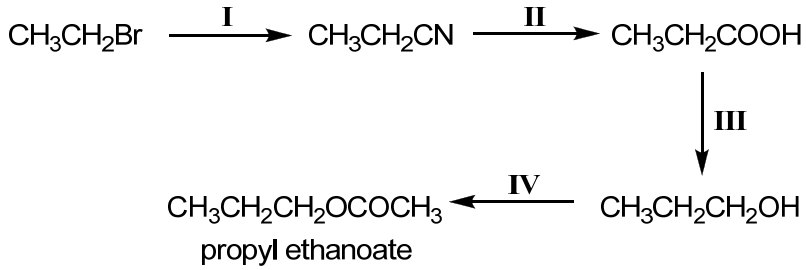
_____

[4]

[Total: 10]

For Examiner's Use

4. Propyl ethanoate is a colourless liquid which gives pears their characteristic odour. It is commonly used in fragrances and as a flavour additive. It can be synthesised from bromoethane in 4 steps:



(a) Suggest reagents and conditions for steps **I**, **II**, **III** and **IV**.

step	*reagents and conditions*
I	
II	
III	
IV	

[4]

(b) State the type of reaction for steps **I** and **III**.

Step **I**: _____ Step **III**: _____

[2]

(c) Ester **W** is an isomer of propyl ethanoate.

$CH_3CH(CH_3)OCOCH_3$
Ester **W**

Suggest a simple chemical test which would enable you to distinguish between ester **W** and propyl ethanoate. You should state the reagents and conditions for the test, and describe how each of the isomers behaves.

Reagents and conditions: _____

_____

Observations: _____

_____

[4]

[Total: 10]

SECTION B

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

5. Formaldehyde, HCHO, is a colourless and pungent gas. Formaldehyde-based materials are used in many industries. The textile industry, for example, uses formaldehyde-based resins to make crease-resistant fabrics.

(a) In view of its toxicity, formaldehyde is not permitted for use as food additives. However, formaldehyde occurs naturally at low levels in a wide range of foods. The World Health Organisation (WHO) has established a Tolerable Daily Intake (TDI) of 5.00×10^{-6} mol kg^{-1} body weight for formaldehyde.

(i) Calculate the TDI in mg kg^{-1} body weight for formaldehyde.

(ii) Assuming that a candy contains 0.04 mg of formaldehyde, calculate the maximum number of candies a child with a mass of 15 kg can consume in a day without exceeding the TDI for formaldehyde.

[3]

(b) Formaldehyde reacts with dichromate(VI) ions, $Cr_2O_7^{2-}$, forming HCOOH and chromium(III) ions, Cr^{3+}.

(i) State the observation for the reaction.

(ii) Write the ion-electron equation for the oxidation of formaldehyde.

(iii) Hence write the balanced equation for the reaction between formaldehyde and $Cr_2O_7^{2-}$.

[3]

(c) In an experiment to determine the enthalpy change of combustion of formaldehyde, a known volume of water was heated using formaldehyde.

(i) Define the term *standard enthalpy change of combustion*.

(ii) Write a balanced equation to represent the enthalpy change of combustion of formaldehyde.

(iii) When 1.00 g of formaldehyde was burned under a container of water, it was found that 200 cm^3 of water was heated from 25.0°C to 40.9°C. The process was known to be only 70% efficient.

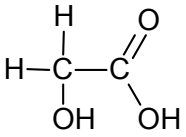
Use these data and values from the *Data Booklet* to calculate the enthalpy change of combustion of formaldehyde.

(iv) Using the value you have calculated in **(c)(iii)** and the following data, calculate the enthalpy change of formation of formaldehyde.

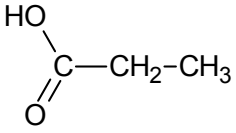
Enthalpy change of formation of CO_2 (g)	-393.5 kJ mol^{-1}
Enthalpy change of formation of H_2O (*l*)	-285.8 kJ mol^{-1}

[7]

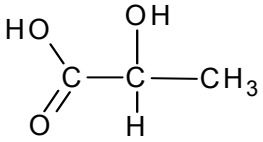
5. (d) The structures of glycolic acid, propanoic acid and lactic acid are shown below.



Glycolic acid



Propanoic acid



Lactic acid

(i) Suggest how glycolic acid can be synthesised from formaldehyde in 2 steps, showing the reagents and conditions, as well as the intermediate.

(ii) Propanoic acid and glycolic acid have similar molar mass. Explain why the melting point of propanoic acid is much lower than that of glycolic acid.

(iii) Suggest how you would distinguish between glycolic acid and lactic acid using a suitable chemical test. State clearly the reagents and conditions used as well as the observations for each of the compounds.

[7]

[Total: 20]

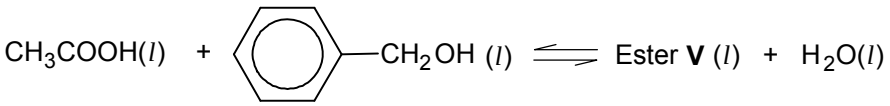
6. (a) (i) Define the term *Bronsted-Lowry base*.

(ii) Ethanoate ion, CH_3COO^-, is the conjugate base of ethanoic acid.
Write an expression for the base dissociation constant, K_b, of ethanoate ion.

(iii) Write two equations to show how the CH_3COOH / CH_3COO^- buffer system can regulate pH.

[4]

(b) Ethanoic acid and phenylethanol react in the presence of hot concentrated H_2SO_4 to form ester **V** as shown in the equilibrium below.



(i) Draw the structure of ester **V**.

(ii) Write an expression for the equilibrium constant, K_c, for the above reaction.

(iii) The K_c for the above reaction at 398K is 9.
0.5 mol of CH_3COOH and 0.5 mol of phenylethanol were mixed in a 1 dm^3 closed vessel at 398K. Calculate the concentration of ester **V** present at equilibrium.

(iv) Concentrated H_2SO_4 was used as a catalyst in the reaction above. Explain how a catalyst can increase the rate of reaction.

6. (b) (v) Other than acting as a catalyst, concentrated H_2SO_4 was also added to increase the yield of ester **V**. Explain how it is able to increase the yield of ester **V**.

[8]

(c) Ethanoic acid is a carboxylic acid and phenylethanol is an alcohol. Explain why ethanoic acid is a stronger acid compared to phenylethanol.

[2]

(d) Phenylethanol reacts with different reagents under different conditions to give different mono-chlorinated products.

Draw the structure of the product when phenylethanol reacts with

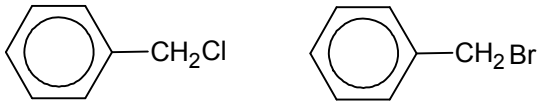
(i) Cl_2(g) in the presence of $AlCl_3$

(ii) Cl_2(g) in the presence of sunlight

(iii) PCl_5 at room temperature

[3]

(e) Both compounds **S** and **T** undergo hydrolysis with hot aqueous NaOH to give phenylethanol.



S **T**

State and explain which compound undergoes hydrolysis more easily.

[3]

[Total: 20]

7. (a) The elements **X** and **Y** can be one of the following Period 3 elements: Na, Mg, Si and P.

Element **X** has an oxide that dissolves slightly in water, forming a weakly alkaline solution. Its chloride dissolves readily in water, forming a slightly acidic solution.

Element **Y** has a crystalline solid oxide with a very high melting point. This oxide is classified as an acidic oxide but it is not soluble in water.

Identify the elements **X** and **Y**. Explain the observations with the aid of relevant balanced equations where necessary.

[4]

(b) Aluminium is another Period 3 element. Its oxide, also known as alumina, is used in organic reactions as a dehydrating agent.

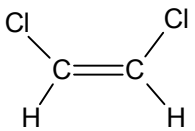
Compound **A**, $C_4H_{10}O$, does not react with acidified $KMnO_4$ but reacts with alumina to give only one product, **B**, with the molecular formula C_4H_8. **B** decolourises aqueous bromine, forming **C**, C_4H_9OBr. **C** does not decolourise acidified $KMnO_4$.

C reacts with hot ethanolic NaCN followed by dilute sulfuric acid to give **D**, $C_5H_{10}O_3$. Upon reaction with concentrated H_2SO_4, **D** forms a sweet-smelling compound **E**, $C_{10}H_{16}O_4$.

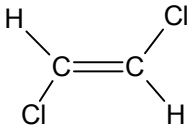
Deduce the structures of **A** – **E**. Explain your reasoning and the chemistry of the reactions involved.

[9]

(c) When a compound is heated over alumina, two isomeric products, **F** and **G**, are formed.



F



G

Compounds **F** and **G** have different boiling points. Explain why.

[3]

7. (d) Compound **A** in part **(b)** can be produced from the reaction of C_4H_9Br with aqueous KOH. The equation for the reaction is as follows:

$$C_4H_9Br + KOH \rightarrow C_4H_{10}O + KBr$$

Experiments were conducted by mixing varying concentrations of the reactants. The results are given in the table below.

Experiment	**$[C_4H_9Br]$ / mol dm^{-3}**	**$[OH^-]$ / mol dm^{-3}**	**Initial rate of reaction / mol dm^{-3} min^{-1}**
1	0.0010	0.10	0.026
2	0.0025	0.10	0.065
3	0.0060	0.50	0.156

(i) Determine the order of reaction with respect to C_4H_9Br and potassium hydroxide.

(ii) Hence state the rate equation.

(iii) Calculate the rate constant, k, stating its units.

[4]

[Total: 20]

END OF PAPER

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