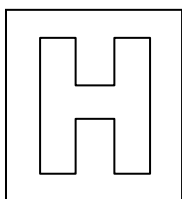


Candidate Name: _____

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2013 Preliminary Examination II

Pre-university 3

H2 CHEMISTRY

9647/02

Paper 2 Structured Questions

Wednesday, 18 Sep 2013
2 hours

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces provided at the top of this page.

Write in dark blue or black pen in the spaces provided.

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

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

Answer **all** questions.

A Data Booklet is provided.

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.

For Examiner's Use	
1	/12
2	/10
3	/13
4	/12
5	/13
6	/12
Total	/72

1 Planning (P)

You are to design an experiment to determine the enthalpy change of reaction between solid $\text{Mg}(\text{OH})_2$ and hydrochloric acid.

You are provided with the following list of apparatus and reagents.

[You may assume that all other common laboratory apparatus not listed below are also available.]

Reagents:

- **FA1:** 2.50 mol dm^{-3} of HCl
- **FA2:** $\text{Mg}(\text{OH})_2$ solid

Apparatus:

- A thermometer with 0.2°C interval
- A 100 cm^3 styrofoam cup **with a lid**
- 50 ml measuring cylinder

- (a) Write a balanced equation (including state symbols) for the reaction between solid $\text{Mg}(\text{OH})_2$ and hydrochloric acid. [1]

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- (b) Given that the **enthalpy change of reaction** between solid $\text{Mg}(\text{OH})_2$ and hydrochloric acid is approximately $-30.0 \text{ kJ mol}^{-1}$, prove with calculations whether 50.0 cm^3 of 2.5 mol dm^{-3} HCl and 1.50 g of $\text{Mg}(\text{OH})_2$ are suitable quantities to use at the start of the experiment. Justify your answer.

[Assuming the specific heat capacity of the solution is $4.2 \text{ J g}^{-1} \text{ K}^{-1}$] [4]

- (c) Hence give a detailed procedure to determine the enthalpy change of reaction between solid $\text{Mg}(\text{OH})_2$ and HCl . [4]

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- (d) Both Group I and Group II hydroxides are white solids. A student accidentally mixes up two **unlabelled** bottles of white solids, known to contain either KOH or Ba(OH)₂. Briefly describe an experiment in which the student can perform in order to determine the identity of the white solids.

You are provided with two unknown colourless solutions both at the same concentration of 1.00 mol dm⁻³, either containing KOH (aq) or Ba(OH)₂ (aq) and **FA1**: 2.50 mol dm⁻³ of HCl. [3]

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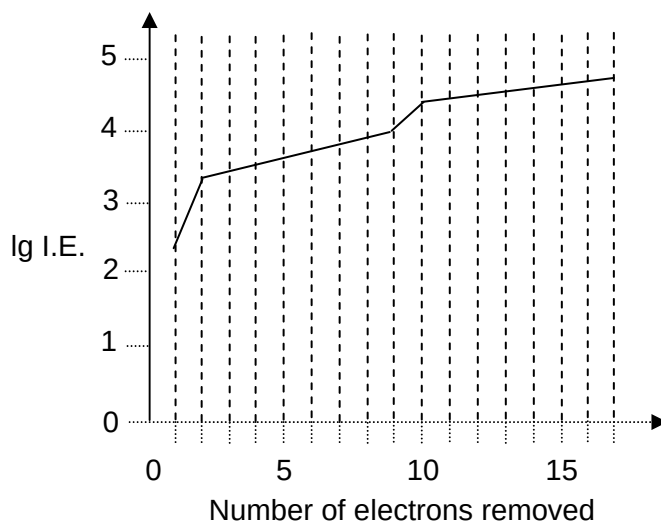
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- 2 The graph shows the logarithm, $\lg$, of the ionization energies for the outermost electrons of element **X** in Period 4.

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- (a) From the graph above, deduce the group in the Periodic Table to which **X** is likely to belong to and explain your reasoning.

Hence, suggest an identity for element **X**.

[2]

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Identity of **X**:

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(b) (i) Sketch a graph for elements of the third period (**sodium to chlorine**) to show how each property changes across the period.

II. Melting Point

Explain your sketches.

[illegible]

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- (ii) State and explain the trend of atomic radius of transition metals across the period from titanium to copper. [8]

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[Total: 10]

- 3 Explain the following observations as fully as you can.

Write equations where appropriate.

- (a) (i) When $\text{NH}_3(\text{aq})$ is added to a solution containing $\text{Cu}^{2+}(\text{aq})$, a light blue precipitate which is soluble in an excess of $\text{NH}_3(\text{aq})$ to form a dark blue solution is formed.

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- (ii) When concentrated hydrochloric acid is added to another solution containing $\text{Cu}^{2+}(\text{aq})$, there is a colour change from blue to pale yellowish-green. No such colour change occurs when concentrated sulfuric acid is added to $\text{Cu}^{2+}(\text{aq})$. [4]

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- (b) 3-bromo-3-methylhexane, $\text{CH}_3\text{CH}_2\text{C}(\text{Br})(\text{CH}_3)\text{CH}_2\text{CH}_2\text{CH}_3$, reacts with ethanolic sodium cyanide to form a mixture that does not rotate light. [2]

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- (c) The entropy of the following systems increases.

[Both systems are kept under constant volumes.]

I. 1 mol of Br_2 (g) is added to 1 mol of N_2 (g) at 298 K.

II. 1 mol of I_2 (g) is heated from 298 K to 373 K.

[2]

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- (d) (i) The kinetics of the chlorination of PCl_3 was investigated in three experiments at constant temperature. The initial rate of the experiment was measured at different concentrations of PCl_3 and Cl_2 . The results are shown in the following table.

Experiment	$[\text{PCl}_3] / \text{mol dm}^{-3}$	$[\text{Cl}_2] / \text{mol dm}^{-3}$	Relative Rate/ $\text{mol dm}^{-3} \text{s}^{-1}$
1	0.005	0.005	1.00
2	0.006	0.006	1.44
3	0.008	0.006	1.92

Show that the units for the rate constant, k , of the above experiment is $\text{mol}^{-1} \text{dm}^3 \text{s}^{-1}$.

- (ii) Phosphorus trichloride, PCl_3 , and NCl_3 react in different ways with water although they each give two products. In the reaction, PCl_3 gives HCl as the only chlorine containing product, while NCl_3 gives HOCl as the only chlorine-containing product. Suggest why PCl_3 and NCl_3 behave differently. [5]

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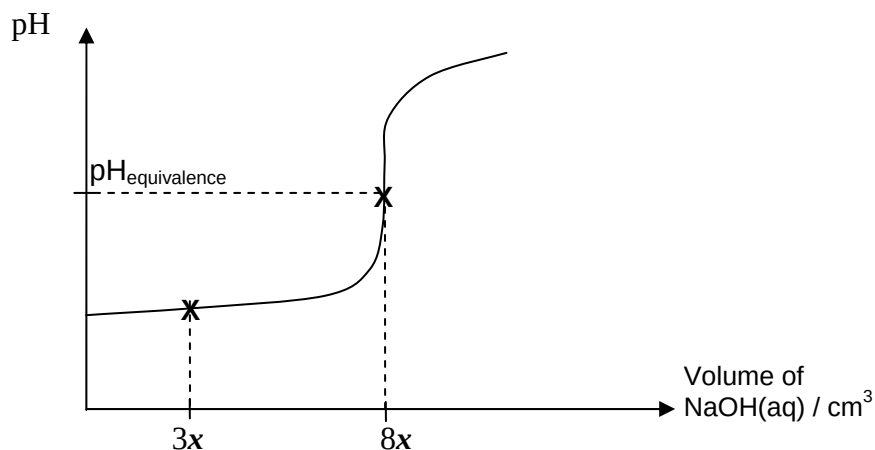
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- 4 A biochemist needs to prepare a $\text{CH}_3\text{COOH} / \text{CH}_3\text{COO}^-\text{Na}^+$ buffer solution to stimulate the growth of a particular fungus.

In order to investigate the composition of a $\text{CH}_3\text{COOH}/\text{CH}_3\text{COO}^-\text{Na}^+$ buffer solution of pH 4.16, the biochemist titrated 25.0 cm^3 of this buffer solution with 1.0 mol dm^{-3} aqueous sodium hydroxide. The graph below shows the titration curve obtained.



Upon the addition of $3x \text{ cm}^3$ of aqueous sodium hydroxide, the buffer solution becomes most effective. The equivalence point of titration is attained when $8x \text{ cm}^3$ of aqueous sodium hydroxide is added.

- (a) Show that the ratio of $[\text{CH}_3\text{COOH}] : [\text{CH}_3\text{COO}^-\text{Na}^+]$ is 4 : 1 in the original buffer solution. [3]

(b) Determine the K_a of CH_3COOH .

[2]

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(c) State and explain if the K_a value of CH_2ClCOOH is higher or lower than the K_a value of CH_3COOH . [2]

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(d) (i) Using your answer in (b), determine the pH of the solution formed when 50.0 cm^3 of $0.100 \text{ mol dm}^{-3} \text{ CH}_3\text{COOH}(\text{aq})$ is mixed with 30.0 cm^3 of $0.100 \text{ mol dm}^{-3} \text{ CH}_3\text{COO}^-\text{Na}^+(\text{aq})$.

- (ii) 2 cm³ of 0.100 mol dm⁻³ of hydrochloric acid was accidentally added to the solution in (d)(i). It was found that the pH of the resulting solution did not differ much from the pH obtained in (d)(i).

Explain why this is so. Write equations to support your answer. [5]

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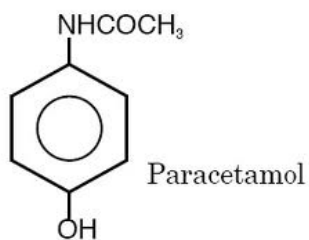
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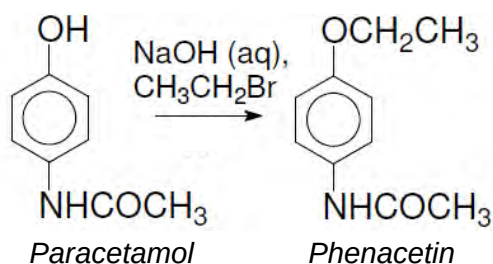
- 5 Paracetamol is classified as a mild painkiller. It is commonly used for the relief of headaches and other minor aches and pains and is a major ingredient in numerous cold and flu remedies.



- (a) Paracetamol can be made from phenol as a starting material. Describe a synthesis route for the production of paracetamol from phenol in no more than 3 steps.

You are to include all intermediates and reagents and conditions used in each step of your synthesis. [5]

- (b) Paracetamol can be converted into another painkiller, Phenacetin, as shown below.



With reference to the mechanism of the reaction, suggest why NaOH(aq) is added in the conversion. [2]

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- (c) Suggest a method by which the following compounds could be distinguished from each other by a chemical test. State the observations you would expect for each compound.

- (i) Paracetamol and Phenacetin

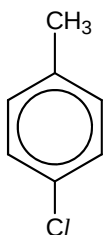
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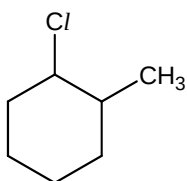
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- (ii)



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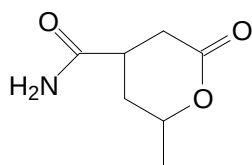
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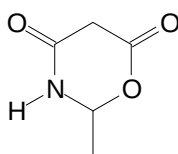
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(iii)



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[6]

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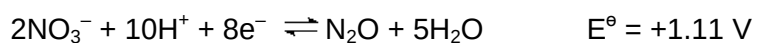
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- 6 Nitrous oxide is naturally present in the atmosphere as part of the Earth's nitrogen cycle. Human activities such as agriculture, fossil fuel combustion, wastewater management, and industrial processes contribute to the amount of N_2O in the atmosphere.
- (a) Draw a fully labelled experimental set-up for a voltaic cell made up of an $\text{NO}_3^-/\text{N}_2\text{O}$ half-cell and a Cu^{2+}/Cu half-cell under standard conditions. Indicate clearly the anode and cathode and show the flow of electrons. [4]

- (b) *The use of the Data Booklet is relevant to this question.*

The standard electrode potential of the $\text{NO}_3^-/\text{N}_2\text{O}$ half-cell is given below:



Calculate the $E^\ominus_{\text{cell}}$ and write an equation for the reaction that occurs. [2]

- (c) Benzene is nitrated by warming it in a mixture of concentrated nitric acid and concentrated sulfuric acid. With the help of equations, describe the mechanism of the nitration of benzene. [4]

- (d) The bromination of benzene occurs via a similar mechanism to that in (c). Iron(III) bromide is required to catalyse the reaction. Suggest why this is so. [2]

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[Total: 12]

END OF PAPER