Class Adm No

Candidate Name:

H

millennia institute

2012 Preliminary Examination II
Pre-university 3

H2 CHEMISTRY **9647/02**

Paper 2 **18 Sept 2012**

2 hours

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

1. Do not turn over this question paper until you are told to do so.
2. Write your name, class and index number in the spaces provided at the top of this page.
3. Write in ***dark blue*** or ***black pen*** in the spaces provided on the Question Paper.
4. You may use a soft pencil for any diagrams or graphs.
5. **DO NOT** use paper clips, highlighters, glue or correction fluid or tape.
6. Answer **ALL** the questions.
7. Give non-exact numerical answers correct to ***3 significant figures***, or ***1 decimal place*** in the case of $\mathbf{M_r}$ and $\mathbf{A_r}$, unless a different level of accuracy is specified in the question.
8. The number of marks is given in brackets [ ] at the end of each question or part question.
9. You are reminded of the need for ***clear presentation*** in your answers and to ***show all working*** in calculations.
10. The use of a calculator is expected, where appropriate.

Paper 2							
Question No	**1 (12m)**	**2 (9m)**	**3 (10m)**	**4 (16m)**	**5 (10m)**	**6 (15m)**	
Marks Obtained							**72**

This question paper consists of 16 printed pages.

[Turn over

1 Planning

The benzenediazonium ion, $C_6H_5N_2^+$, reacts with water as shown in the equation.

$$C_6H_5N_2^+ (aq) + H_2O (l) \rightarrow C_6H_5OH (aq) + N_2 (g) + H^+ (aq)$$

At temperatures below 10 ºC, the reaction is very slow. However, nitrogen gas is evolved at a measureable rate at temperatures of 20 ºC and above.

In this experiment, you are provided with an aqueous solution containing 0.100 mol dm^{-3} of the benzenediazonium ion at a temperature below 10 ºC.

You are required to design an experiment to deduce the order of reaction with respect to $C_6H_5N_2^+$ of an aqueous solution at 20 ºC and an atmospheric pressure of 101 kPa.

(a) Define the term *order of reaction*. [1]

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(b) Outline the steps you would take to determine the order of reaction with respect to $C_6H_5N_2^+ (aq)$ at 20 ºC. In your plan, include the following details:

- a suitable volume of $C_6H_5N_2^+ (aq)$ used,
- measurement(s) to be taken,
- plotting of a suitable graph, if any. [5]

(c) Draw a labelled diagram of the experimental set-up.

[You may assume that you are given common apparatus found in a school laboratory.] [2]

(d) Describe how you will use the results obtained to determine the order of reaction with respect to $C_6H_5N_2^+$ (aq). [2]

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(e) Identify one potential hazard in this experiment and suggest the safety precaution you would take to overcome this. [2]

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[Total: 12 marks]

2 **(a)** A lower secondary Science student described an atom of Silicon as having ‘fourteen bees buzzing around a space the size of a football stadium, as though they are being trapped.’

(i) Explain using Chemistry concepts, what do the bees in the description represent and what stopped the bees from flying away from the stadium?

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(ii) The teacher commented that the student’s description of Silicon was incomplete. What is missing from the student’s description of Silicon?

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(iii) ^{28}Si, ^{29}Si, ^{30}Si are isotopes of Silicon.
Explain why isotopes of Silicon undergo identical chemical reactions? [3]

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(b) Amongst all the elements in Period 3 of the periodic table, Silicon has the highest melting point. Sketch a graph to illustrate the trend of the melting points of elements in Period 3. Explain your sketch. [4]

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(c) Silicon reacts with oxygen to form silicon dioxide as a possible product.

In dentistry, a composite material based on SiO_2 has been developed to be used as dental fillings.

(i) State one property of SiO_2 that makes it suitable for use as dental fillings.

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(ii) Draw a diagram to illustrate the type of bonding involved in SiO_2. [2]

[Total: 9 marks]

3 Ammonia gas decomposes into nitrogen and hydrogen when passed over a platinum gauze. The rate of decomposition is found to be independent of the partial pressure of ammonia at very high pressures, but the rate was directly proportional to the partial pressure of ammonia at low pressures.

(a) Explain this observation as far as you can. [2]

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(b) Given that 45% of ammonia dissociated into nitrogen and hydrogen at moderately high temperatures, and a total pressure of 1 atm, calculate the value of K_p, stating its units. [3]

(c) Ammonia, nitrogen and hydrogen are non-ideal gases.

(i) State two assumptions of the kinetic theory as applied to an ideal gas.

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(ii) Which of these three gases deviates the most from an ideal gas? Explain your answer.

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(iii) For a given fixed mass of an ideal gas, sketch graphs of:

I: P against V at constant T (where P represents pressure)

II: V against *pV* at constant T (where *p* represents density) [5]

[Total: 10 marks]

4 The reaction between phenol and benzoyl chloride produces an **ester** with the formula $C_6H_5COOC_6H_5$. Hydrogen chloride is also formed in this reaction.

Name of Compound	Chemical formula	M_r
Phenol	C_6H_5OH	94.0
Benzoyl chloride	C_6H_5COCl	140.5
?	$C_6H_5COOC_6H_5$	198.0

The crude (impure) ester produced in the reaction can be purified by *recrystallisation in ethanol*. A typical yield, based on benzoyl chloride is 70%.

[Additional info:
Melting point of ester: 68- 70 ºC
Boiling point of ester: 298- 299 ºC]

(a) State the name of the ester that is produced in the reaction. [1]

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(b) Explain why this reaction will not occur if benzoic acid was used instead of benzoyl chloride. [1]

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(c) In this experiment, only 70% of benzoyl chloride is converted into to the ester.

(i) Calculate the minimum mass of benzoyl chloride needed to form 5 g of the ester.

(ii) Hence, calculate the minimum mass of phenol needed in the reaction. [2]

(d) Briefly describe how the crude (impure) ester produced can be purified by *recrystallisation in ethanol*.

(i)

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(ii) Suggest and explain a method that can be used to check the purity of the ester produced. [4]

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(e) Another ester, **P** (M_r = 116) used in synthetic fruit flavors, is subjected to hydrolysis to give a monoprotic acid, **Q** and an alcohol, **R**.

When 1.00 g of **Q** is titrated with 0.500 mol dm^{-3} NaOH, 33.0 cm^3 of NaOH is required for neutralization. **R** reacts with alkaline aqueous iodine to give a precipitate **S**. Compound **R** exists as a pair of isomers, both of which are oxidized to give **T** which also reacts with alkaline aqueous iodine to give the same precipitate **S**, and a solution **U**.

Identify the structures **P**, **Q**, **R**, **S**, **T** and **U**, explaining your deductions clearly. [8]

[Total: 16 marks]

5 This question discusses metals in Group **I** and Group **II** of the Periodic table.

(a) For a group **I** element, the ease with which the following reaction occurs is indicated by its electrode potential, E^{θ}. **M**(s) ® $\mathbf{M}^{+}$ (aq) + e^{-} ---------- Reaction (**I**)

Calculate the enthalpy change of Reaction (**I**) for Li and Na, using values given below as well as relevant data from the data booklet.

Element (**M**)	ΔH_{at} (**M**) / kJ mol^{-1}	$\Delta H_{hydration}$ ($\mathbf{M}^{+}$) / kJ mol^{-1}
Li	159	-957
Na	107	-841

[3]

(b) Comment on the relationship between the enthalpy change of Reaction (**I**) obtained in (**a**) and the E^{θ} values given in the data booklet for Li and Na. [2]

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(c) The melting points of Group II oxides are given in the table below.

Oxide	Melting point / ºC
MgO	2852
CaO	2614
SrO	2430
BaO	1918

Explain the trend in the melting points. [2]

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(d) Describe the reactions, if any, for magnesium and calcium with cold water, writing equations, with state symbols, for any reactions taking place. [3]

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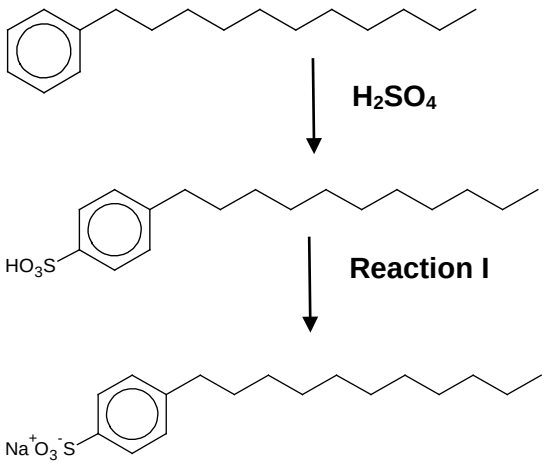
[Total: 10 marks]

6 Synthetic detergents (anionic, cationic and non-ionic) consist of a hydrocarbon chain and polar group. As a surfactant, the synthetic detergent is more effective than conventional soap in hard water – water that contains dissolved minerals such as Ca^{2+} and Mg^{2+}.

Anionic detergents

Anionic detergents contain groups with a negative charge such as $Na^+SO_3^-$. An example of synthesis of a detergent sodium-n-dodecylbenzenesulfonate is as follows:

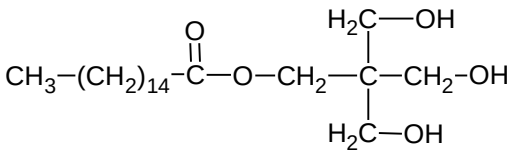


Cationic detergents

Cationic detergents contain positively charged groups and can be found in hair conditioners. Keratin, a protein which contains negatively-charged groups which can be found on the surface of hair, binds strongly to the hydrophilic ends of cationic detergents. The hydrophobic ends of the surfactant molecules then act as the new hair surface. One example of such a detergent is trimethylhexadecylammonium chloride, $[CH_3(CH_2)_{15}N(CH_3)_3]^+ Cl^-$.

Non-ionic detergents

Non-ionic detergents are commonly used in dish-washing liquids. An example is pentaerythrityl palmitate:



(a) State possible reagents and conditions to synthesize $[CH_3(CH_2)_{15}N(CH_3)_3]^+$ from

(i) $CH_3(CH_2)_{15}NH_2$.

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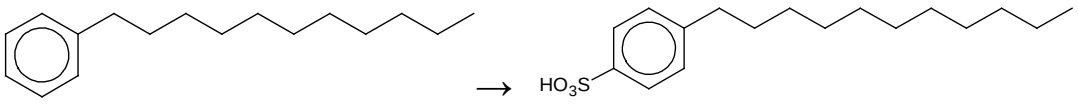
(ii) Name and draw the mechanism for the following synthesis.



[5]

(b) Suggest why non-ionic detergents are commonly used in dish-washing liquids. [1]

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(c) Describe a chemical test that can be used to distinguish between sodium-n-dodecylbenzenesulfonate and pentaerythrityl palmitate.
You are to include all reagents, conditions and expected observations. [2]

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(d) Apart from detergents or soap, cleaning products may also contain enzymes to degrade protein-based stains. Enzymes are proteins with a specific biological activity that are determined by their primary, secondary, tertiary and quaternary structures.

(i) Apart from its function as an enzyme, state one other function of proteins.

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(ii) Briefly describe with a well-labeled diagram, one example of a secondary structure of a protein. [3]

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(e) The effectiveness of enzymes can be reduced by the addition of heavy metal ions such as Hg^{+} or Pb^{2+}.

(i) Explain this phenomenon.

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(ii) Pb^{2+} typically forms complexes that are coloured. Explain why this is so. [4]

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[Total: 15 marks]

END OF PAPER