RIVER VALLEY HIGH SCHOOL
YEAR 6 PRELIMINARY EXAMINATION (II)

CANDIDATE NAME									
CLASS	6								
CENTRE NUMBER	S					INDEX NUMBER			

H2 CHEMISTRY 9647/02

Paper 2 Structured Questions **14 September 2015**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, class, centre number and index number on all the work you hand in.
Write in dark blue or black pen on both sides of paper.
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 in the space provided.
A Data Booklet is provided. Do NOT write anything on it.

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									
Paper 2									
Question Number	1	2	3	4	5	6			Total
Marks	/12	/14	/14	/8	/9	/15			/72
Paper 1		/40		Paper 3		/80		Total	/192

This document consists of **20** printed pages.

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1 Heavy metals, in the form of soluble ions, are common contaminants of industrial wastewaters. Due to their toxicity, they are typically removed prior to wastewater discharge. The heavy metal contents of wastewaters can be effectively removed to acceptable levels by precipitating the metal in an insoluble form.

(a) Each of the sample solutions, **P** and **Q**, contains a type of heavy metal ion. The ion is either silver(I) or zinc.

The following shows the results of a chemical test on lead(II) ions and the two unknown samples.

Test	**P**	**Q**	**Lead(II) ion**
To 1 cm^3 of sample in a test-tube, add potassium chloride solution, followed by excess aqueous ammonia.	No precipitate formed.	White ppt formed is soluble in excess aqueous ammonia.	White ppt formed is insoluble in excess aqueous ammonia.

(i) Write an equation, with state symbols, for the reaction involving lead(II) ion.

…….. [1]

(ii) Deduce the identity of ion **Q** and explain the observations reported.

Q: ……..

Explanation:

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……... [2]

(ii) Suggest a chemical test to confirm the identity of **P**. Describe the expected observation.

Chemical Test:

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Observation:

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…….... [2]

(b) The wastewater from a metal smelter contains high level of lead(II) ions. It is also likely to contain some silver(I) ion and zinc ions.

The concentration of lead(II) ion in the wastewater can be determined using precipitation gravimetric method. Prior to the experiment, pre-concentration is carried out on the wastewater to increase the concentration of lead(II) ions in the sample. Then, suitable reagents are selected to selectively precipitate lead(II) ions from the concentrated sample solution. The concentration of lead(II) ions in the original sample can be calculated from the mass of this precipitate.

Using all the information provided, plan a precipitation gravimetric experiment to determine the concentration of lead(II) ions in untreated waste sample.

You are given the use of common laboratory apparatus and the following chemicals.

Chemicals:

- 10 cm^3 of aqueous sample obtained by pre-concentrating 5 dm^3 of wastewater.
- 0.10 mol dm^{-3} aqueous potassium chloride
- Any other common reagents in the laboratory at 1.0 mol dm^{-3}

A preliminary calculation shows that about 9 cm^3 of potassium chloride solution is required for precipitation.

Your plan should include details of:

- how an accurate mass of the precipitate containing lead(II) can be obtained;
- how you would check that all lead(II) ions are precipitated.

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(c) **(i)** Given that the mass of $PbCl_2$ obtained is 0.102 g. Calculate the concentration of lead(II) ions in untreated wastewater.

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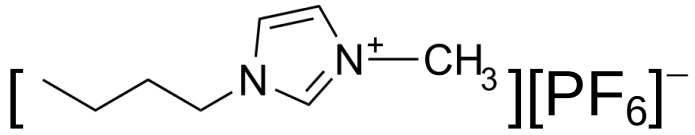
……... [2]

[Total: 12]

2 Compounds with a giant ionic structure usually have high melting points. However, scientists have developed low melting point ionic compounds which are liquids at room temperature. An example of this would be:

1-Butyl-3-methylimidazolium hexafluorophosphate

($BMIM^+$ PF_6^-)



(a) Draw a suitable diagram to illustrate the shape of the hexafluorophosphate anion.

Suggest a value for the bond angle.

[2]

(b) $BMIM^+PF_6^-$ has a melting point of –8 °C.

In comparision, NaC*l* has a melting point of 801 °C.

In terms of structure and bonding, explain the difference in melting points between both compounds.

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..... [2]

(c) Imidazole is used in the manufacture of the ionic liquid $BMIM^+PF_6^-$. Imidazole can be considered as a monoprotic weak base with pK_b value of 6.95.

(i) Explain what is meant by the term pK_b as applied to a weak base **B**.

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(ii) Calculate the pH of a solution when 25 cm^3 of 0.100 mol dm^{-3} of imidazole is mixed with 20 cm^3 of 0.125 of mol dm^{-3} HNO_3.

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(d) An alloy of A*l*, Fe and Zn may be used as a catalyst for the production of $BMIM^+PF_6^-$.

Some information of the three metals present in the alloy are given below:

	Metal 1	Metal 2	Metal 3
Density/ g cm^{-3}	2.07	7.13	7.87
Melting point/ °C	660	420	1538

Suggest the identities of Metal 1, 2 and 3.

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(e) A sample of the alloy in **(d)** is first dissolved in excess sulfuric acid, giving a pale green solution **A**. This mixture is then treated with excess NaOH(aq), and then filtered. The residue **B** is then dissolved in NaCN(aq) solution, giving a pale yellow solution.

(i) State the formula of the complex ion responsible for the pale green colour of solution **A.**

…….. [1]

(ii) Identify the residue **B**.

…….. [1]

(iii) Write an equation to show the reaction between residue **B** and NaCN(aq).

…….. [1]

[Total: 14]

3 **(a)** The decomposition of oxides of nitrogen with the general formula N_xO_y

usually decomposes with first-order kinetics to give nitrogen dioxide.

The reaction rate of a first-order reaction can be expressed as a derivative of the concentration of the reactant with respect to time.

$$\text{Rate} = k[N_xO_y]$$

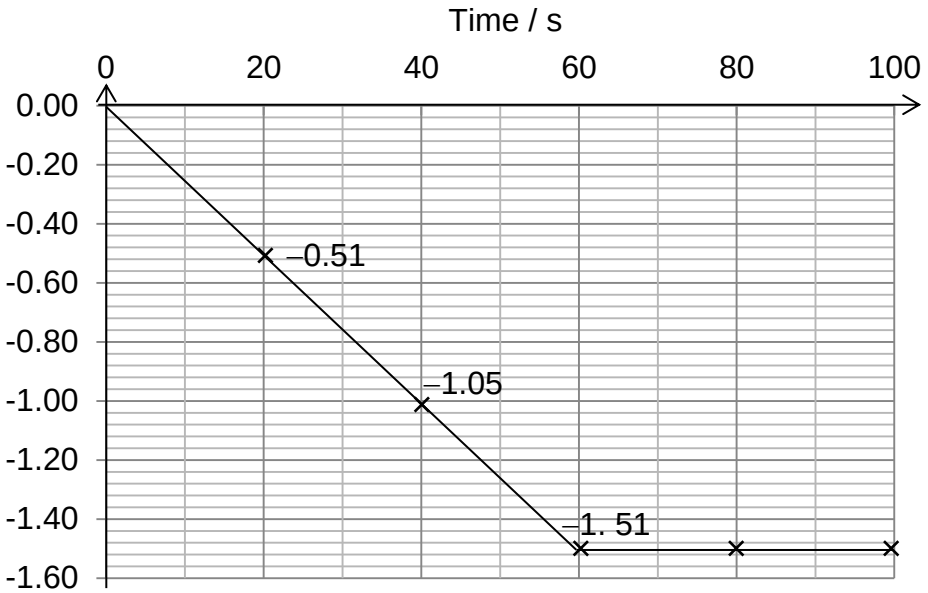
$$-\frac{d[N_xO_y]}{dt} = k[N_xO_y]$$

$$\int_{[N_xO_y]_0}^{[N_xO_y]} -\frac{d[N_xO_y]}{dt} = -k\int_0^t dt$$

$$\ln\frac{[N_xO_y]}{[N_xO_y]_0} = -kt$$

(where $[N_xO_y]_0$ refers to the initial concentration of N_xO_y used)

1.00 mol dm^{-3} of dinitrogen tetraoxide, N_2O_4 was left to decompose at 373 K. The following graph was obtained.



(i) Write a balanced equation with state symbols for the decomposition of 1 mole of N_2O_4 at 373 K.

…… [1]

(ii) From the first 60 s of the experiment, find the rate constant of the decomposition of N_2O_4, giving its units.

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…… [1]

(iii) Hence, calculate the half-life of N_2O_4 at 373 K, giving your answer to the

nearest second.

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(iv) The above results were obtained based on a continuous method, where the total pressure was monitored over 100 s. The pressure measured at every 20 s was used to calculate the concentration of N_2O_4 left.

Suggest another experimental method and briefly explain how it can be used to determine the rate of the decomposition of N_2O_4.

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..... [2]

(b) **(i)** Complete the table below, and sketch a labelled graph of $[N_2O_4]$ versus time. You should include the information from **(a)(iii)**.

Time / s	$[N_2O_4]$ / mol dm^{-3}
0	1.00
20	
40	0.35
60	0.22
80	0.22
100	0.22

[3]

(ii) From the completed table in **(b)(i)**, show that the degree of dissociation of N_2O_4 is 78 %.

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…… [1]

(iii) Using your answer from **(a)(i)**, construct an expression to represent the equilibrium constant of the decomposition of N_2O_4. Calculate its value at 373 K, stating its units clearly.

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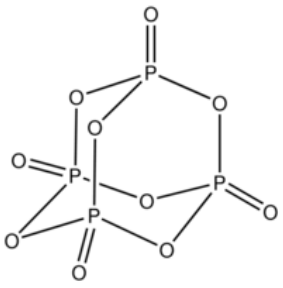
…… [3]

(c) **(i)** Nitrogen dioxide can also be obtained by the combustion of diatomic nitrogen at high temperatures.

Draw the dot-and-cross diagram for NO_2.

[1]

(ii) From the same group, phosphorus burns in excess oxygen to give P_4O_{10}.



Explain why nitrogen cannot form N_4O_{10}.

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…… [1]

[Total: 14]

4 Data related to oxides of Period 3 elements are shown in the table below.

Oxide	Sodium oxide	Magnesium oxide	Silicon dioxide	Sulfur trioxide
Melting point / ^{o}C	1275	2800	1700	17

(a) In terms of structure and bonding, explain the difference in melting points between silicon dioxide and sulfur trioxide.

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(b) Describe the reaction of sodium oxide and magnesium oxide with water. Write equations when appropriate and predict the pH of the resultant solutions.

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(c) Aluminium oxide is an amphoteric oxide. Write two equations which demonstrate the amphoteric behavior of aluminium oxide.

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[Total: 8]

5 **(a)** The following cell notation shows a set up between an acidified $Cr_2O_7^{2-}(aq)/Cr^{3+}(aq)$ half-cell and an unknown $\mathbf{M}^{2+}(aq)/\mathbf{M}(s)$ half-cell.

$$\mathbf{M}(s) \mid \mathbf{M}^{2+}(aq) \parallel Cr_2O_7^{2-}(aq), Cr^{3+}(aq) \mid Pt(s)$$

The standard cell potential was found to be +1.77 V.

(i) Using the *Data Booklet*, calculate the standard electrode potential of the $\mathbf{M}^{2+}(aq)/\mathbf{M}(s)$ half-cell. Hence, identify **M**.

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…… [2]

(ii) Draw a fully labelled set up of the cell under standard conditions.

[3]

(b) An element **Y** has two isotopes of masses, 69 and 70, in the ratio 1:2. When a current of 2.5 A was passed through molten electrolyte of **Y**Cl_x for 50 minutes, 1.81 g of the metal **Y** was deposited at the cathode. Using the results of the experiment, calculate the value of x in the electrolyte **Y**Cl_x.

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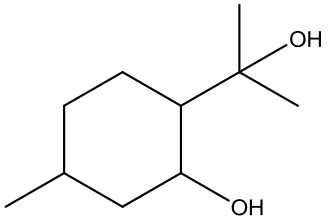
…… [4]

[Total: 9]

6 **(a)** p-Menthane-3,8-diol also known as PMD, is an active ingredient used in insect repellents. PMD is found in essential oil from the leaves of Eucalyptus citriodora, a tree native to Australia. The oil can be extracted by grounding the leaves with mortar, pestle and sand, together with the solvent of cyclohexane.



PMD

(i) Suggest a reason why PMD can dissolve in cyclohexane.

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……. [1]

(ii) Suggest a method how sand and other solid residue could be removed from the mixture.

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(iii) At this stage, anhydrous magnesium sulfate and calcium chloride is added to it. Suggest a reason for it.

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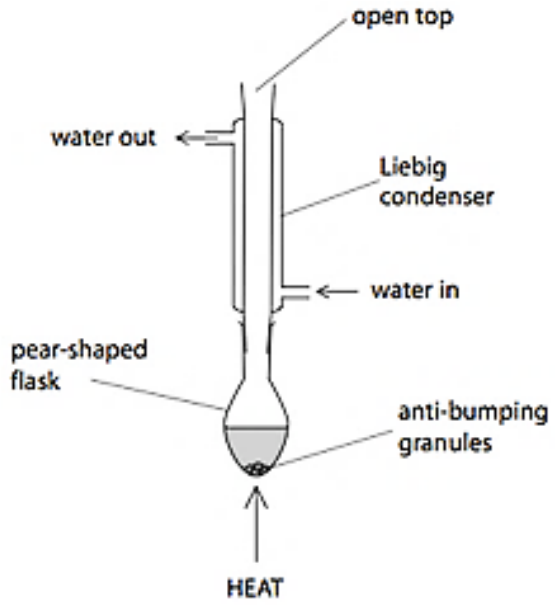
……. [1]

(iv) A student suggested using the following apparatus to remove the cyclohexane from the mixture.



Explain in terms of processes that occur in the above apparatus, why this method is unsuitable for removing cyclohexane. Suggest how the apparatus can be modified for a successful separation.

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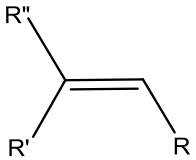
…… [3]

(b) PMD can be chemically synthesized using citronella, extracted from lime leaves, as the starting molecule. The synthesis involves Prinz reaction as one of the steps.

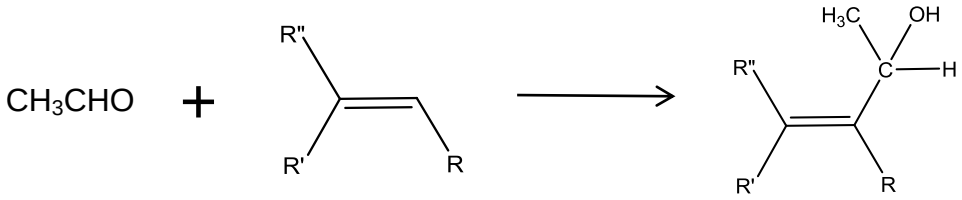
The Prinz reaction can be described in a few steps as shown below:

- The carbonyl O in ethanal, CH_3CHO, is protonated (H^+) using TsOH (a strong acid). This is immediately followed by the breaking of π bond and the formation of a carbocation A.



- An alkene, , will react with the carbocation A via an electrophilic attack to form carbocation B.
- A proton will be be lost from carbocation B to form the unsaturated molecule as shown in the overall equation below.

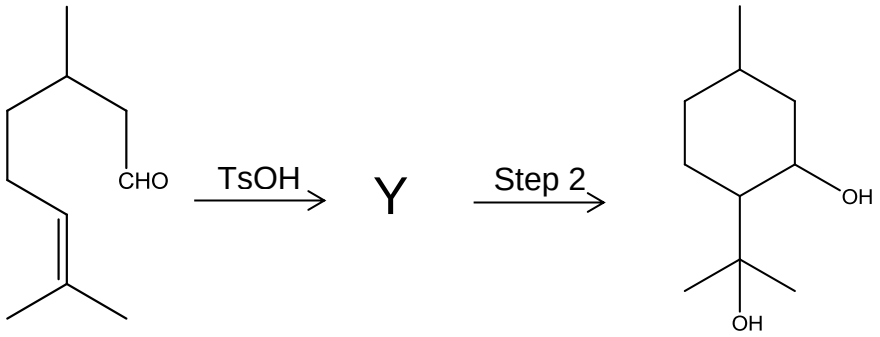
Overall equation:



Using the information given above, draw out the three-step full mechanism for the reaction of ethanal with the given alkene in the presence of TsOH, showing all charges and using all curly arrows to show the movement of electron pairs.

[3]

(c) A 2-step synthesis pathway of PMD from citronella is given below:



citronella PMD

State the structure of Y and the reagents and conditions used for Step 2.

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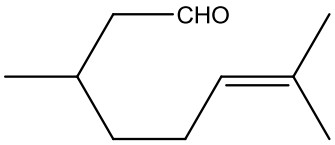
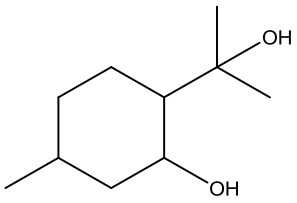
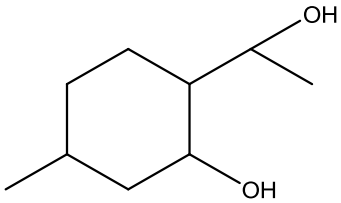
…….. [2]

(d) In another synthesis pathway for PMD, a possible side-product is 2-(1-hydroxyethyl)-5-methylcyclohexanol.

Using the table below, suggest 2 simple chemical tests to identify PMD, citronella and 2-(1-hydroxyethyl)-5-methylcyclohexanol, stating the observations clearly in the space provided.

	Test 1	Test 2
Compound	…… …… …… …… …… ……	…… …… …… …… …… ……
 citronella		
 PMD		
 2-(1-hydroxyethyl)-5-methylcyclohexanol		

[4]

[Total: 15]