RAFFLES INSTITUTION
2017 YEAR 6 PRELIMINARY EXAMINATION

Higher 1

CANDIDATE NAME			
CLASS		INDEX NUMBER	

CHEMISTRY 8872/02

Paper 2 **11 September 2017**
2 hours

Candidates answer Section A on the Question Paper.

Additional Materials: Answer paper
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.
The use of an approved scientific calculator is expected, where appropriate.
A Data Booklet is provided. Do not write anything on it.
You are reminded of the need for good English and clear presentation in your answers.

Section A
Answer **all** the questions on the question paper.

Section B
Answer any **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		
Paper 1		/ 30
Paper 2	**A1**	/ 10
	A2	/ 7
	A3	/ 10
	A4	/ 13
	B5	/ 20
(circle the questions you have answered in Section B)	**B6**	/ 20
	B7	/ 20
Sub-total		/ 80
Total		**/ 110**

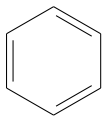
This document consists of **18** printed pages.

Section A (40 marks)

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

1 Benzene is an important industrial chemical and is used in a wide range of manufacturing processes. Over time our understanding of the structure and bonding of benzene has changed and various models have been proposed.

In 1865, Kekulé proposed that the structure of benzene was a ring of alternating double and single bonds, but there was considerable evidence to suggest that Kekulé's model may not be correct.



Kekulé structure of Benzene

(a) State two evidence that led scientists to doubt the model proposed by Kekulé.

……..……..……..

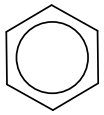
……..……..……..

……..……..……..

……..……..……..

……..…….. [2]

(b) Alternative models of benzene were proposed after Kekulé's structure. The current accepted structure is shown below.



Describe the bonding in the structure of benzene as understood today in terms of orbital overlap. You may draw a diagram to illustrate your answer.

……..……..

……..……..

……..……..

……..……..

……..……..

……..…… [3]

(c) Benzene is an additive in non-leaded petrol. Calculate the minimum volume of oxygen gas required for the complete combustion of 24.0 g of benzene.

[All volumes are measured at s.t.p. conditions.]

[3]

(d) Benzene can react to form bromobenzene. Write an equation for this reaction and state the reagents and conditions necessary for the reaction to occur.

equation: ……

reagents and conditions: ……

[2]

[Total: 10]

2 The following data was obtained in a series of experiments investigating the rate of the reaction between compounds **A** and **B** at a constant temperature.

experiment	initial concentration of **A** / mol dm^{-3}	initial concentration of **B** / mol dm^{-3}	initial rate/ mol dm^{-3} s^{-1}
1	0.12	0.26	2.10×10^{-4}
2	0.36	0.26	1.89×10^{-3}
3	0.72	0.13	3.78×10^{-3}

(a) Show how this data can be used to deduce the rate equation for the reaction between **A** and **B**.

rate equation: ……

[5]

(b) With the aid of a sketch of the Boltzmann distribution curve, explain how an increase in temperature increases the rate of reaction between compounds **A** and **B**.

……..……..

……..……..

……..……..

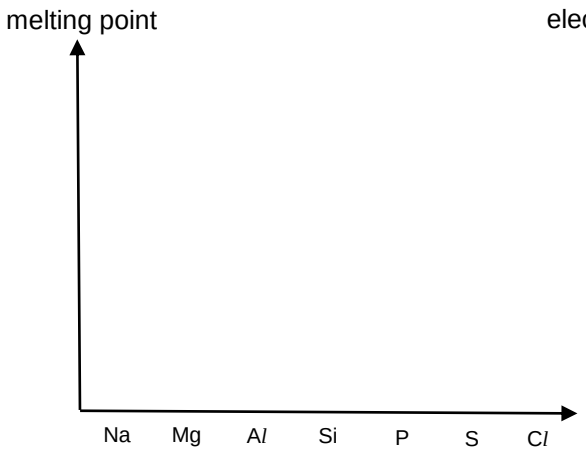
……..……..

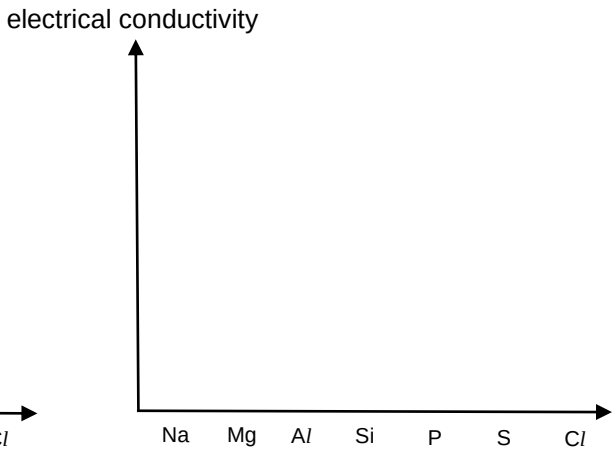
……..……..

……..…… [2]

[Total: 7]

3 **(a)** On each of the grids below, sketch the general trends of the properties of the elements across the third period of the Periodic Table. No scale is specified on the vertical axis.





[2]

(b) With reference to structure and bonding, identify and explain which element in the third period has the

(i) highest melting point

……..……..……..

……..……..……..

..……..……..……[1]

(ii) greatest electrical conductivity

……..……..……..

……..……..……..

..……..……..……[1]

(c) Aluminium can react with chlorine to form aluminium chloride.

(i) Write an equation to show the reaction of aluminium with chlorine.

……[1]

(ii) Melting points of AlF_3 and $AlCl_3$ are given below.

compound	melting point / ^oC
AlF_3	1290
$AlCl_3$	192

By considering the type of structure and bonding present, explain why the two aluminium halides have different melting points.

……

……

……

……

……

……[3]

(d) In the liquid and gas phases, aluminium chloride dimerises to form Al_2Cl_6 via the formation of a dative covalent bond.

(i) Explain why aluminium chloride is able to form dative covalent bonds.

……

……

……

……[1]

(ii) Draw a dot-and-cross diagram to show the bonding within a molecule of Al_2Cl_6.

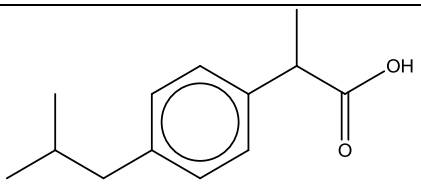
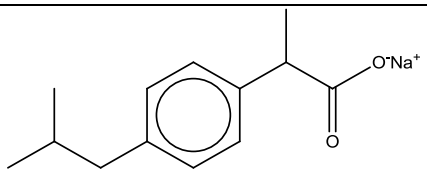
[1]

[Total: 10]

4 Ibuprofen is a drug used for the treatment of pain and fever.

Ibuprofen is often taken orally where they will be absorbed and metabolised in the gut. Alternatively, ibuprofen can also be taken as its sodium salt which shows an increased rate of absorption as compared to ibuprofen.

Some data for ibuprofen and sodium ibuprofen are shown below.

	ibuprofen	sodium ibuprofen
chemical structure		
molar mass / g mol^{-1}	206.0	228.0
solubility in water / g dm^{-3}	0.021	100

(a) Explain why ibuprofen has a lower solubility in water as compared to sodium ibuprofen.

……

……

……

……

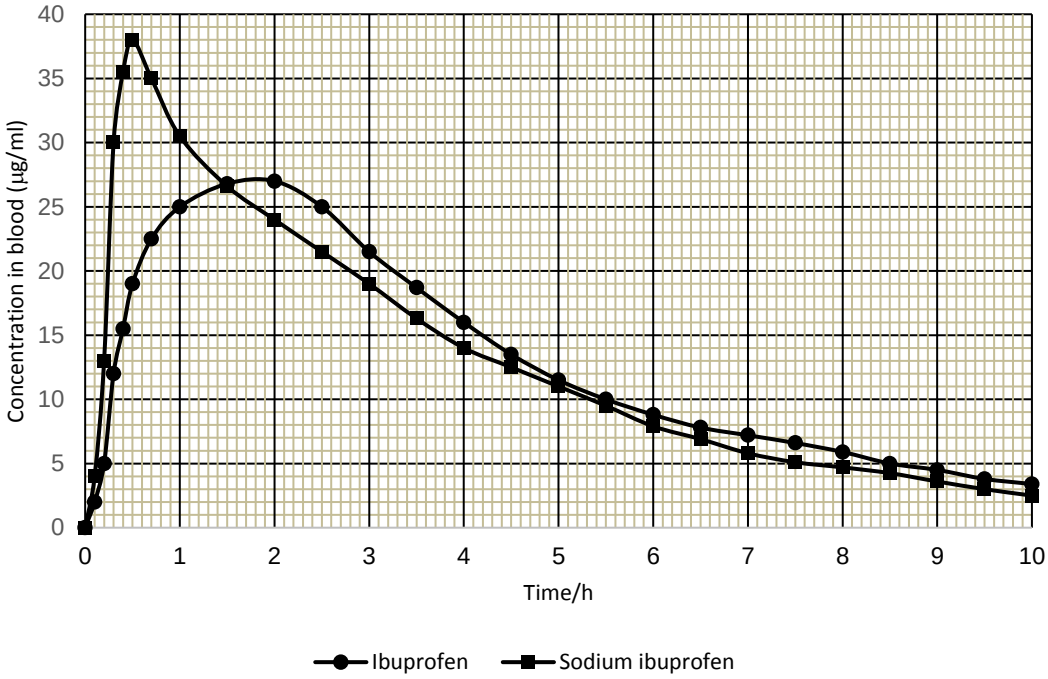
……

……

……[3]

(b) When a drug is consumed, it will enter the bloodstream. The concentration of a drug in blood is measured in μg/ml.

The graphs below show the mean concentrations (in μg/ml) of ibuprofen and sodium ibuprofen after equivalent doses were consumed separately at t=0.



(i) From the graphs above, state how long it takes for ibuprofen and sodium ibuprofen to reach their highest concentrations.

ibuprofen: ……h sodium ibuprofen: ……h

[1]

(ii) Calculate the highest concentration of ibuprofen reached in the blood sample, in mol dm^{-3}.
[1 g = 10^6 μg; 1 dm^3 = 1000 ml]

highest concentration: …… mol dm^{-3}

[2]

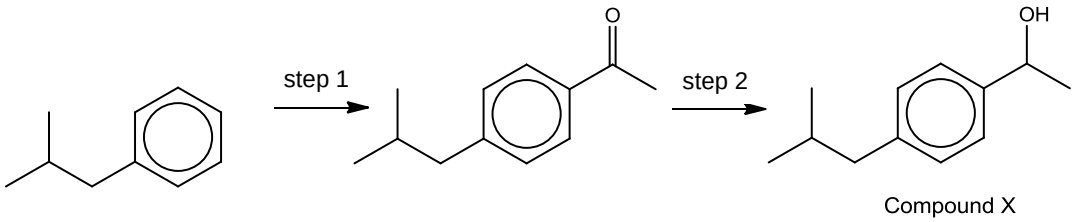
(iii) ***After*** reaching its highest concentration, the concentration of sodium ibuprofen starts to decrease due to metabolism.

Using the graph, show that the metabolism of sodium ibuprofen follows first order kinetics and calculate the rate constant for the metabolism process.

rate constant: …….

[2]

(c) The following shows a possible reaction pathway for the synthesis of compound **X**, a precursor of ibuprofen.



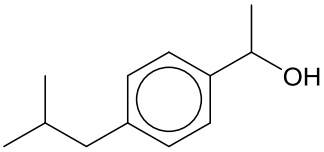
Compound X

(i) Suggest the type of reaction which occurs in step 1 and 2 of the synthesis.

	reaction type
step 1	
step 2	

[2]

(ii) Suggest a three–step route for the synthesis of ibuprofen from compound **X**, stating the reagents and conditions for each step, and giving the structures of the intermediate compounds.

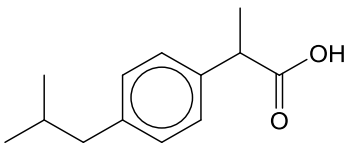


compound **X**

step 1

step 2

step 3



ibuprofen

	reagents and conditions
step 1	
step 2	
step 3	

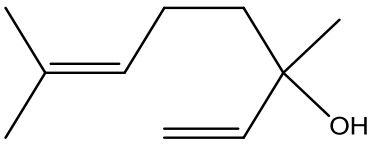
[3]

[Total: 13]

Section B (40 marks)

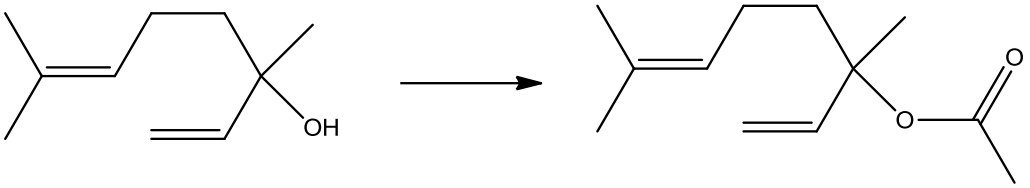
Answer **two** questions from this section on separate answer paper.

5 Linalool, $C_{10}H_{18}O$, commonly found in coriander oil, has the following structure.



linalool

(a) Linalool can be converted to lavender oil as shown below.



lavender oil

State the reagents and conditions for the conversion of linalool to lavender oil. [1]

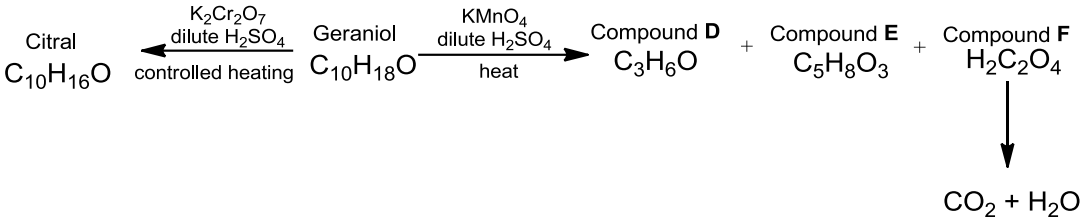
(b) Linalool reacts with excess hydrogen and nickel catalyst to produce compound **C** which has a lily–like aroma.

Draw the structure and give the IUPAC name of compound **C**. [2]

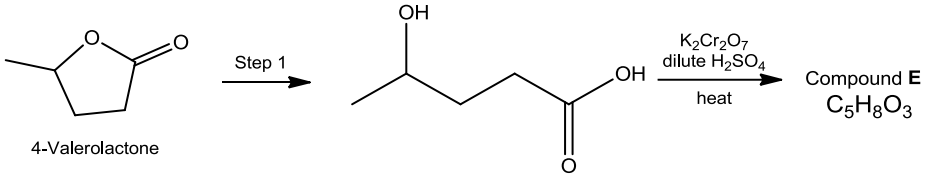
(c) Draw the structural formula of the **major** product formed when linalool is reacted with an excess of gaseous hydrogen bromide. [2]

(d) A structural isomer of linalool is geraniol which is found in rose oil. Geraniol can exist as a pair of cis-trans isomers.

Geraniol undergoes oxidation under different conditions as shown below.



Compound **E** can be obtained from 4-Valerolactone as shown below.



(i) Draw the structure of compound **E**. [1]

(ii) State the reagents and conditions in step 1. [1]

(iii) Given the following information,

- both citral and compound **D** give a positive test with 2,4-dinitrophenylhydrazine.
- compound **D** gives yellow precipitate with aqueous alkaline iodine.
- only citral gives a positive test with Tollens' reagent.
- compound **F** gives effervescence with aqueous sodium carbonate.

deduce the structures of geraniol, citral, compounds **D** and **F**, with reasoning. [8]

(iv) Write an equation for the reaction between compound **D** and 2,4-dinitrophenylhydrazine. [1]

(e) **(i)** Write an equation for the hydrogenation of ethanal and use relevant data from the *Data Booklet* to calculate a value for the enthalpy of hydrogenation for ethanal. [3]

(ii) By using enthalpy changes of formation data, the theoretical value of the hydrogenation of ethanal was calculated to be -161.5 kJ mol^{-1}.
Suggest a reason for the discrepancy in the theoretical value and the value calculated in **(e)(i)**. [1]

[Total: 20]

6 Fluorite is a mineral composed of calcium fluoride, CaF_2. It is commonly used for making aerosol propellants and fire retardants.

(a) The calcium in calcium fluoride exists as the Ca^{2+} ion.

(i) State the full electronic configurations of a calcium atom, Ca, and a calcium ion, Ca^{2+}. [2]

(ii) Using data from the *Data Booklet*, state and compare the values of the atomic and ionic radii of calcium. Explain why they differ. [2]

(b) Describe, by means of a diagram, how the paths of the separate beams of

(i) Ca^{2+} and

(ii) F^-,

are affected on passing through an electric field which is at right angles to their direction of travel. You should relate clearly the magnitude and the direction of deflection of each beam to the others. [2]

(c) ^{19}F is the only stable, naturally occurring *isotope* of the element. There are other radioactive isotopes, with ^{18}F having the longest half-life. It undergoes positron decay to give element **Z**, according to the equation as shown:

$$^{18}_{9}F \rightarrow {}^{x}_{y}Z + {}^{0}_{1}e$$

(i) What do you understand by the term *isotope*? [1]

(ii) Give the values of *x* and *y*, and hence identify element **Z**. [2]

(d) **(i)** Write a chemical equation to represent the lattice energy of CaF_2. [1]

(ii) The lattice energy of calcium fluoride is -2630 kJ mol^{-1}. Suggest, with reasons, how the magnitude of the lattice energy of calcium fluoride might compare to that of calcium oxide. [2]

(e) **(i)** The characteristic reactions of halogenoalkanes may be described as *nucleophilic substitution*. Explain why halogenoalkanes are susceptible to this type of reaction. [2]

(ii) Write an equation to show the reaction of chloroethane with excess alcoholic ammonia. Draw the displayed formula of the organic product obtained. [2]

(iii) State and explain how the rate of reaction in **(e)(ii)** changes when chloroethane is replaced by iodoethane. [2]

(iv) Suggest a simple chemical test to distinguish between chloroethane and iodoethane. [2]

[Total: 20]

7 Chemicals are commonly used for more effective cleaning of surfaces.

(a) Acid cleaners are classified by their pH level and are mainly used for the removal of inorganic deposits.

Glycolic acid, $HOCH_2COOH$, is preferred over hydrochloric acid, HC*l*, for use on many metals and surfaces.

(i) Explain in terms of its structure why glycolic acid is acidic. [2]

Solutions containing same concentrations of glycolic acid and HC*l* were tested for corrosion on carbon steel and stainless steel. The results are shown below.

	% mass loss	
test metal	glycolic	HC*l*
carbon steel	0.17	2.03
stainless steel	0.008	0.53

(ii) Based on the above data, explain the differences in behaviour between glycolic acid and hydrochloric acid. [2]

(iii) The pH of a given solution of glycolic acid is 0.1. Calculate the the hydrogen ion concentration, $[H^+]$, of this solution. [2]

(b) Potassium hydroxide and ammonia are common alkaline cleaning agents. Alkaline cleaners can dissolve fats, oils, and protein-based substances.

(i) Calculate the pH of a 0.125 mol dm^{-3} solution of potassium hydroxide. [2]

Ammonia is manufactured industrially from the Haber Process, where nitrogen and hydrogen react as follows.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(ii) Describe this process including the catalyst involved, the conditions used, and the reasons why these particular conditions are chosen. [5]

A mixture of 0.105 mol of nitrogen and 0.150 mol of hydrogen was mixed in a 1.5 dm^3 container and allowed to reach equilibrium at a particular temperature.

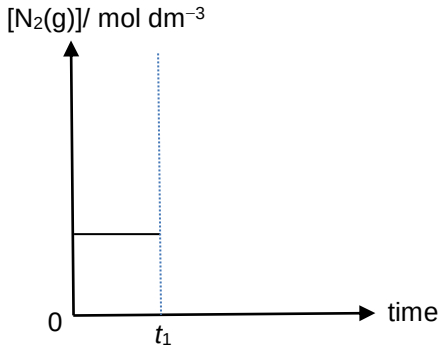
At equilibrium there was 0.09 mol of nitrogen present.

(iii) Explain, in terms of reaction rates, what is meant by a reaction which has reached equilibrium. [1]

(iv) Calculate the equilibrium constant, K_c, including units, if any, for this equilibrium. [5]

(v) The concentration of nitrogen in the equilibrium mixture determined in **(iv)** was increased at time, t_1, and the mixture was then allowed to re-establish equilibrium, at the same temperature.

Copy the diagram below and complete the graph to illustrate how the concentration of nitrogen changes with time when the stated change was made to the equilibrium system at time t_1.



[1]

[Total: 20]

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