H

NANYANG JUNIOR COLLEGE
JC 2 Preliminary Examinations
Higher 1

CANDIDATE NAME

CLASS

TUTOR'S NAME

CHEMISTRY 8872/02

Paper 2 **22 September 2014**

2 hours

Candidates answer on the Question Paper

Additional Materials: Answer Paper
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the 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.

Section **A**
Answer **all** questions.

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

A Data Booklet is provided.
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	
1	/ 20
2	/ 8
3	/ 12
Total	/ 40

For examiner's use only

Section A

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

1 A gas is said to exhibit *ideal* gas behavior if it obeys the **ideal gas equation**

$$pV = nRT$$

where p = pressure of gas in atm,
V = volume of gas in dm^3,
n = amount of gas (mol),
R = 0.0821 dm^3 atm K^{-1} mol^{-1} (a constant),
and T = temperature in K.

(a) A 2.00 dm^3 flask contains oxygen at 1.20 atm and 314 K.

(i) Use the ideal gas equation to find the amount of oxygen in the flask.

(ii) Hence calculate the mass of oxygen in the flask.

[3]

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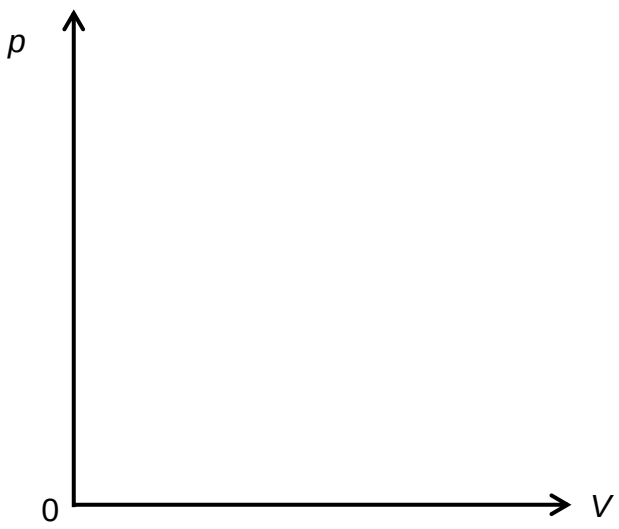
(b) The data below were derived using the ideal gas equation for 1 g of hydrogen.

p / atm	V / dm^3	T / K
1.0	12.3	300
1.4	17.6	600
2.1	5.9	300
3.6	6.8	600
4.8	2.6	300
5.6	4.4	600

(i) How does p vary with V for 1 g of hydrogen at a constant temperature?

.....

(ii) Sketch the graphs of p against V for 1 g of hydrogen at 300 K and at 600 K on the same axes below.
Label each graph.



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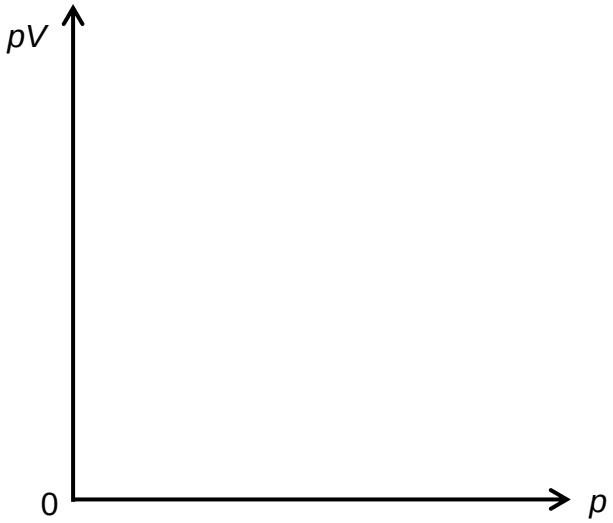
(iii) Sketch the graph of pV against p for 1 g of hydrogen at 450 K.



[4]

(c) Oxygen gas behaves ideally because the intermolecular forces of attraction are very weak. On the other hand, the intermolecular forces in methanol vapour cause it to behave less ideally.

(i) What are the intermolecular forces of attraction in each substance?

Oxygen .....

Methanol vapour .....

(ii) Draw a labelled diagram to show the forces of attraction between two molecules of methanol in the vapour state.

[5]

For examiner's use only

(d) The ideal gas equation can be used to derive a relationship for the relative molecular mass of a gas.

$$M_r = \frac{mRT}{pV}$$

where m is the mass of the gas in grams.

A 0.458 g sample containing a gaseous mixture of $AlCl_3$ and Al_2Cl_6 takes up a volume of 54 cm^3 at a temperature of 98 °C and a pressure of 1 atm.

(i) Draw a dot-and-cross diagram for the $AlCl_3$ molecule.

(ii) Draw the structural formula of the Al_2Cl_6 molecule.

(iii) Calculate the average M_r of the mixture.

(iv) Hence calculate the percentage by mass of Al_2Cl_6 in the mixture.

[8]

[Total: 20]

For examiner's use only

2 **(a)** Explain what is meant by the term *order of reaction*.

.....

..... [1]

(b) Hydrogen peroxide reacts with iodide ions in acidic solution as shown below.

$$H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \rightarrow 2H_2O(l) + I_2(aq)$$

The results of some investigations of the rate of this reaction are shown below.

Experiment number	$[H_2O_2]$ / mol dm^{-3}	$[H^+]$ / mol dm^{-3}	$[I^-]$ / mol dm^{-3}	Relative initial rate / mol dm^{-3} s^{-1}
1	0.030	0.050	0.060	1.80
2	0.020	0.060	0.050	1.00
3	0.0375	0.060	0.060	2.25
4	0.025	0.060	0.050	1.25

(i) Use the above data to determine the order of reaction with respect to

- H_2O_2
- H^+
- I^-

(ii) Hence, write a rate equation for the above reaction.

.....

[4]

For examiner's use only

(c) With the aid of a sketch of the Boltzmann distribution, explain how an increase in temperature increases the rate of a chemical reaction.

.....

.....

.....

.....

[3]

[Total: 8]

For examiner's use only

3 Esters are compounds which provide the flavour of many fruits and the perfumes of many flowers.

(a) The ester $CH_3(CH_2)_2CO_2CH_3$ contributes to the aroma of apples.

(i) State the reagents and conditions needed for the hydrolysis of this ester.

.....

(ii) Write the equation for the hydrolysis of this ester.

.....

.....

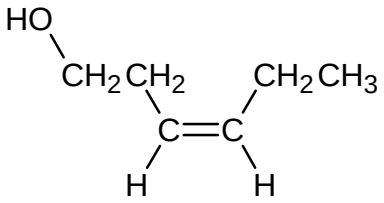
(iii) Apart from their use as perfumes and food flavourings, state **one** major commercial use of esters.

.....

.....

[3]

(b) Leaf alcohol is a stereoisomer that can form when insects such as caterpillars eat green leaves.



(i) Draw the other stereoisomer of leaf alcohol.

(ii) Draw the displayed formula of the ester formed when leaf alcohol reacts with ethanoic acid.

[3]

For examiner's use only

(c) **(i)** Deduce the relative molecular mass, M_r, for leaf alcohol.

(ii) Leaf alcohol was reacted to form a product with an M_r value 18 units less. Suggest a structure for this product and deduce the type of reaction that took place.

[3]

(d) Describe a simple chemical test to distinguish between leaf alcohol and your product in **(c)(ii)**. Draw the structures of the products of any reactions that occur.

[3]

[Total: 12]

Section B

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

4(a) Sodium hydrogencarbonate decomposes on heating to form sodium carbonate. It is difficult to measure the enthalpy change of this reaction directly.

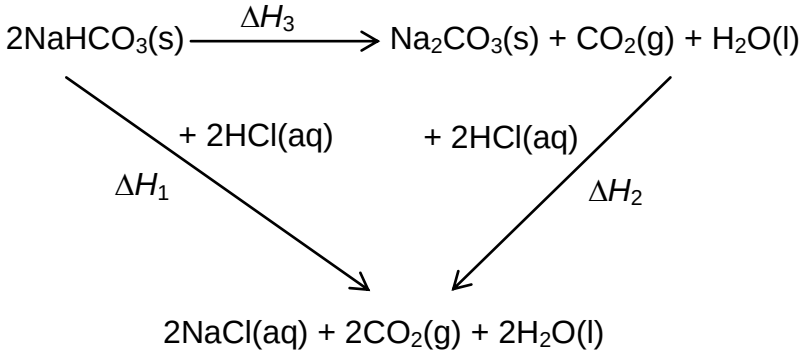
$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$$

One method of determining this enthalpy change is to react known amounts of sodium hydrogencarbonate and sodium carbonate, separately with excess dilute hydrochloric acid.

(i) 0.48 g of sodium hydrogencarbonate was added to 25 cm^3 of 0.100 mol dm^{-3} of dilute hydrochloric acid. The temperature rise was found to be 6.8 K and the process was found to be only 85% efficient.

Calculate the enthalpy change for the reaction when one mole of sodium hydrogencarbonate reacts with dilute hydrochloric acid.

The standard enthalpy change for the reaction between sodium carbonate and dilute hydrochloric acid is found by a similar method to be –321.6 kJ mol^{-1}.



(ii) Using the energy cycle provided, calculate the value of ΔH_3.

(iii) Hence, sketch an energy profile diagram for the decomposition of sodium hydrogencarbonate.

[7]

(b) Sea water is a source of chemicals. The most abundant chemical dissolved in sea water is sodium chloride. Compounds of magnesium and bromine are also present. Magnesium occurs at 1300 parts per million (ppm) and bromine at 60 ppm by mass.

The solution left after crystallising sodium chloride from sea water is even richer in bromine, and contains around 2.2 g dm^{-3} of bromine. Bromine is extracted from this solution by passing in chlorine gas. The mixture is acidified to prevent the following hydrolysis of bromine.

$$Br_2(aq) + H_2O(l) \rightleftharpoons 2H^+(aq) + Br^-(aq) + BrO^-(aq) \qquad \Delta H > 0$$

The bromine can be separated by heating the solution to collect bromine vapour which is then condensed, or by blowing air through the solution.

(i) Show by calculation that a solution containing 2.2 g dm^{-3} of bromine is richer in bromine than one containing 60 ppm.
[1 ppm = 1 mg / L]

(ii) Explain how a low pH level would affect the hydrolysis of bromine.

(iii) Explain how an increase in temperature would affect the equilibrium position for the hydrolysis of bromine.

[5]

(c) Compound **A** has the molecular formula of $C_9H_{11}Br$, which has three positional isomers.

On reaction with hot ethanolic potassium hydroxide, **A** gives only a single product, **B**.

B reacts with cold acidified potassium manganate(VII) to give **C**.

C reacts with hot acidified potassium dichromate to give **D**, $C_9H_8O_3$.

D gives an orange precipitate with 2,4-dinitrophenylhydrazine, but does not react with Fehling's solution. One mole of **D** reacts with one mole of propanol with hot concentrated sulfuric acid to give **E**, $C_{12}H_{14}O_3$.

Deduce the structures of the compounds **A** to **E**. Explain your reasoning for the reactions involved.

[8]

[Total: 20]

5(a) Sodium chlorate(V), $NaClO_3$, is a colourless crystalline compound, which is used as a bleaching and oxidising agent. The main commercial use for sodium chlorate(V) is for making chlorine dioxide, ClO_2. The largest application of ClO_2, which accounts for about 95% of the use of chlorate, is in bleaching of pulp. Industrially, sodium chlorate(V) is produced by the electrolysis of a hot sodium chloride solution.

(i) Draw a dot-and-cross diagram to illustrate the bonding in $NaClO_3$.

(ii) State the bond angle of the ClO_3^- ion and use the VSEPR (Valence Shell Electron Pair Repulsion) theory to predict its shape.

An alternative method to form sodium chlorate(V) involves a reaction between chlorine and warm aqueous NaOH in a 1:2 mole ratio. In this reaction, water, sodium chloride and sodium chlorate are formed.

(iii) Write a balanced equation for the above reaction.

(iv) Use oxidation numbers to explain what type of reaction has occurred in this alternative method.

[7]

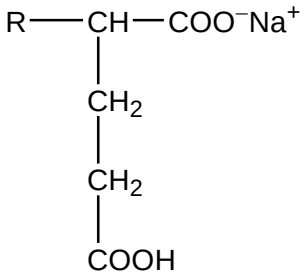
(b) An organic compound **S** (M_r = 112) contains by mass 64.3% carbon, 7.1% hydrogen, and 28.6% oxygen. **S** undergoes an addition reaction with bromine in a 1:1 mole ratio. It also reacts with alkaline aqueous iodine to give a yellow precipitate and reacts with hot $KMnO_4$ to give **T**, $C_4H_6O_3$, as the only organic product.

(i) Determine the molecular formula of **S**.

(ii) Deduce with reasoning, a possible structure for compound **S** and **T**.

[7]

(c) A solution containing sodium glutamate functions as a buffer solution. The structure of the salt is shown below:



sodium glutamate

Assume the R group in the above compound is inert

(i) What is meant by a buffer solution?

(ii) With the aid of ionic equations, explain how the above solution reacts with H^+ and OH^- ions.

(iii) Predict the solubility of sodium glutamate in water, explaining the types of bonding involved.

[6]

[Total: 20]

6(a) Octet rule is a chemical rule of thumb that states that atoms of main-group elements tend to combine in such a way that each atom has eight electrons in its valence shell, giving it the same electronic configuration as a noble gas.

(i) There are exceptions to the octet rule. Suggest examples of species with

- odd number of valence electrons
- less than 8 valence electrons

(ii) The compound SF_2 readily reacts with fluorine to give SF_4. Suggest reasons why MgF_2 does not react with more fluorine to give MgF_4.

[5]

(b) An element in the second period (lithium to neon) in the Periodic Table often shows a diagonal similarity to the element a group higher in the third period (sodium to argon). Discuss this statement with special reference to beryllium and aluminium.

[6]

(c) The molecular formula of an organic compound is $C_3H_6O_3$. 1 mol of this compound reacts with sodium to give 1 mol of hydrogen.

Draw the structure for the compound using

(i) displayed formula,

(ii) skeletal formula, and

(iii) stereochemical formula to show spatial arrangement of bonds, atoms and groups with respect to central carbon atom

[3]

(d) State examples of an oxidising agent and a reducing agent used in organic reactions. For each reaction, give the conditions used, write the structural formulae of the organic reactants and products. You must suggest different organic compounds for the oxidation and reduction reactions.

[6]

[Total: 20]