TAMPINES JUNIOR COLLEGE

Preliminary Examinations 2008

CHEMISTRY (Higher 1) 8872/2

PAPER 2

Thursday **21 August 2008** 2 hours

Additional materials: Writing Paper
Graph Paper
Data Booklet

INSTRUCTIONS TO CANDIDATES

Write your name and Civics Group on all the work you hand in.
Write in dark blue or black pen.

Section A
Answer **all** questions in the space provided.

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

At the end of the examination, fasten the answers to Section B to Section A.

The number of marks is given in brackets [ ] at the end of each question or part question.

Name : _____

CG : _____

Question	Marks
Section A	
B4	
B5	
B6	
TOTAL	/ 80

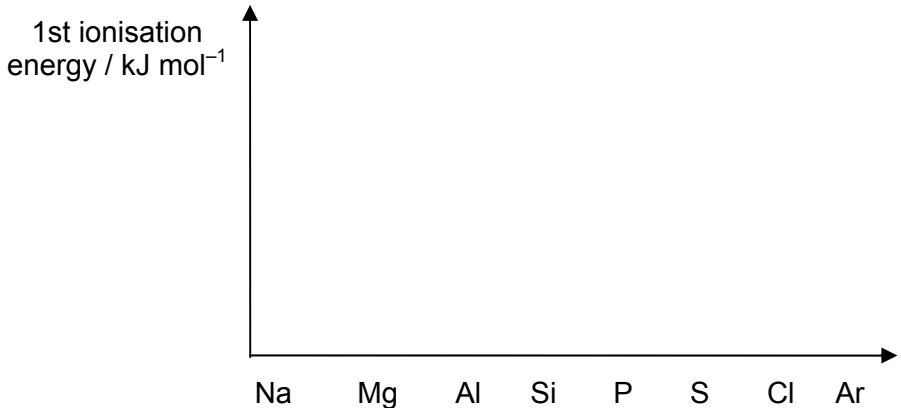
This document consists of **10** printed pages.

[Turn over

Section A

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

1 (a) (i) On the grid given below, sketch the general trends of the first ionisation energy of the elements across the third period of the Periodic Table. Your sketch is expected to be clear though qualitative only.



(ii) Explain the general trend of your sketch in (a)(i).

_____

_____

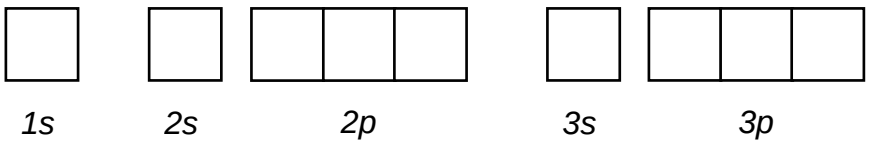
_____

_____

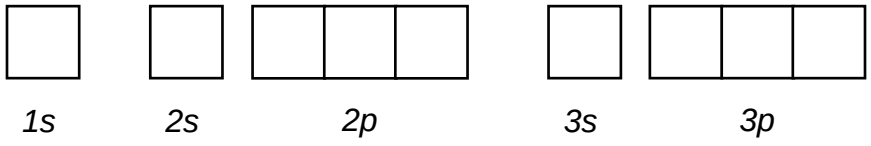
[3]

(b) (i) In the spaces provided, draw the electronic configuration of phosphorous and sulphur.

phosphorous



sulphur



(ii) Briefly explain the relative magnitudes of the first ionisation energies of phosphorous and sulphur.

_____

_____

[3]

(c) The elements in Period 3 range from metals on the left of the periodic table to non-metals on the right.
Describe a chemical property of an oxide of magnesium which shows that it is a metal **and** a chemical property of an oxide of sulphur which shows that it is a non-metal. Give chemical equations where relevant.

_____

_____

_____

_____

_____

_____ [4]

(d) When diluting sulphuric acid with water, care must be taken because the process is highly exothermic:

$$H_2SO_4(l) \rightarrow H_2SO_4(aq) \qquad \Delta H < 0$$

(i) Given that the enthalpy change of formation of $H_2SO_4(l)$ and $H_2SO_4(aq)$ are -814 kJ mol^{-1} and -908 kJ mol^{-1} respectively, calculate the enthalpy change of reaction for the dilution.

(ii) 1.00 mol of $H_2SO_4(l)$ was diluted to a volume of 1.00 dm^3 of $H_2SO_4(aq)$ in a calorimeter. Assuming that the density of the final solution is 1.06 g cm^{-3} and that its specific heat capacity is 3.50 J g^{-1} K^{-1}, what would be the temperature rise of the solution in the calorimeter?

[4]

[Total: 14]

2 **(a)** **(i)** State what is meant by a *buffer solution*.

_____

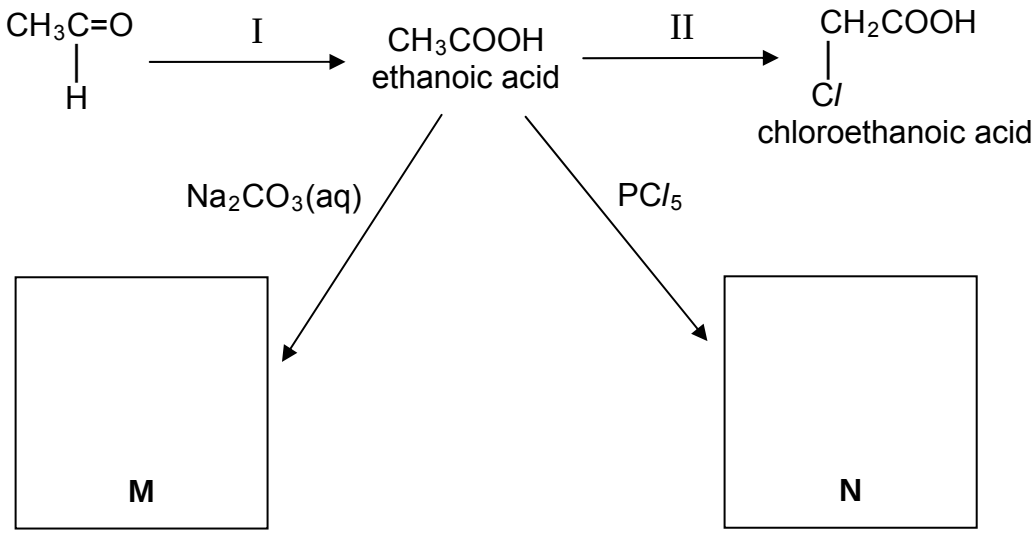
_____

(ii) Explain, using equations, how an aqueous mixture of ethanoic acid, CH_3COOH, and sodium ethanoate, $CH_3COO^-Na^+$, can act as a buffer solution

- on the addition of acid,
- on the addition of alkali.

[3]

(b) The diagram below shows a reaction scheme involving ethanoic acid.



(i) Give the displayed formulae of compounds **M** and **N** in the spaces provided.

(ii) State the reagents and conditions required for conversions I and II.

I : _____

II : _____

(iii) Ethanoic acid is soluble in water. Explain this observation with the aid of a diagram.

(iv) Chloroethanoic acid is a stronger acid than ethanoic acid.
State which acid has the lower pK_a value and explain the difference in acid strength.

_____

_____

_____

_____

_____

(v) How do you think the strength of fluoroethanoic acid, CH_2FCOOH, compares with that of chloroethanoic acid? Briefly explain your answer.

_____

[10]

[Total: 13]

[continued on next page

3 Hydrogen accounts for 90% of the atoms in the universe. It has three naturally occurring isotopes: ordinary hydrogen (^{1}H or protium) which is the most abundant, deuterium (^{2}H or D) and tritium (^{3}H or T) which is radioactive. All three occur as diatomic molecules, examples of which are H_2 and D_2, who have boiling points of 20.39 K and 23.67 K respectively.

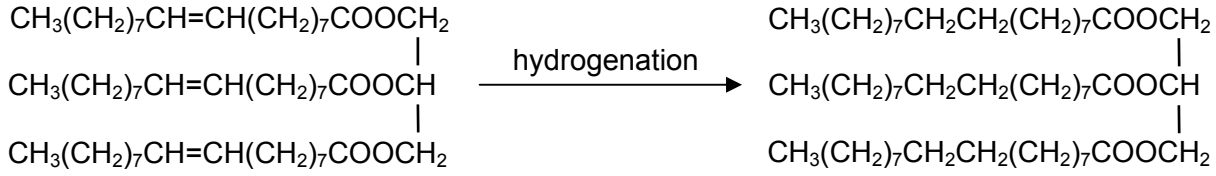
Hydrogen gas (H_2) is produced on an industrial scale worldwide, with about 3 x 10^{12} dm^3 (at s.t.p.) being produced annually in the United States alone. All the production methods are energy intensive. Some of the methods employed include electrolytic and thermal methods.

The most common thermal method of producing hydrogen gas is a two-step method using water and a simple hydrocarbon. Many modern American plants use methane as the hydrocarbon. The first step involves the following reaction which is nickel-catalysed.

$$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g) \qquad \Delta H = +206 \text{ kJ mol}^{-1} \qquad (1)$$

In regions such as Scandanavia, hydrogen gas is produced using an electrolytic method. In this method, electricity is used to decompose water into hydrogen and oxygen gas. Under typical operating conditions, it takes about 400 kJ of energy to produce 1 mole of hydrogen gas.

One of the major uses of hydrogen is the hydrogenation of the alkene (C=C) bonds in liquid oils to form solid fats and margarine. The equation below illustrates the complete hydrogenation of a typical "mono-unsaturated" oil.

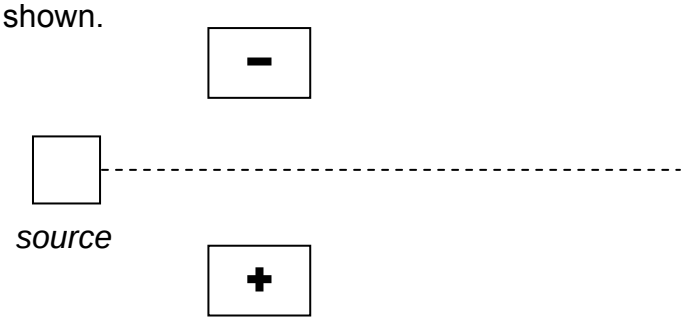


"mono-unsaturated" oil

The conditions of the hydrogenation process can be carefully controlled to give "partial hydrogenation."

A concern about the hydrogenation process is that the "trans fats" produced pose health risks when consumed. The double bonds in unsaturated fats and oils tend to have the groups around them arranged in the "cis" form. However, the relatively high temperatures used in the hydrogenation process tend to flip some of the carbon-carbon double bonds into the "trans" form.

(a) In an experiment, separate beams of protium and deuterium **<u>ions</u>** were passed through an electric field. Sketch on the diagram below, the expected paths taken by each beam. Your sketch should be clearly labeled and the relative magnitude of the angles of deflection clearly shown. [2]



(b) Suggest an explanation for the difference in the boiling points of diatomic protium and deuterium.

_____

_____ [1]

(c) (i) Suggest a reason for the choice of methane as the hydrocarbon in the thermal method of producing hydrogen.

_____

_____

(ii) Use the given enthalpy change for reaction (1), together with relevant data from the Data Booklet to calculate a value for the carbon-oxygen bond energy in carbon monoxide, CO.

[4]

(d) (i) How many moles of hydrogen gas are produced in the United States annually?

(ii) If the electrolytic method was used to produce hydrogen gas in the United States, how much energy would be required annually?

(iii) Write the equation, including state symbols, for the production of hydrogen gas by the electrolysis of water.

_____

[3]

(e) (i) What do you think could be the conditions required for the hydrogenation of the liquid oils by hydrogen gas?

_____

(ii) In the space below, draw the structure of a possible product of "partial" hydrogenation of the "mono-unsaturated" oil.
[You may use 'R' to represent the parts of the oil which do not undergo reaction.]

(iii) What property of the alkene double bond (C=C) gives rise to the existence of 'trans fat'?

_____

[3]

[Total : 13]

Section B (40 marks)

Answer **two** of the three questions in this section on separate paper.

4 (a) When hydrogen chloride is eliminated from 2-chlorobutane, three isomeric alkenes with the formula of C_4H_8 are produced.

(i) Suggest reagents and conditions for this reaction.

(ii) Draw the structural formulae the three alkenes produced.

[4]

(b) (i) Draw structural formulae of compounds **A**, **B** and **C** in the following reaction scheme.

$$CH_3CH_2CH_2Cl \xrightarrow{NaCN} \mathbf{A} \xrightarrow{H^+/heat} \mathbf{B} \xrightarrow[\text{dry ether}]{LiAlH_4 \text{ in}} \mathbf{C}$$

(ii) State and explain how the rate of the reaction changes when chloropropane is replaced by bromopropane.

[5]

(c) State the reagents and conditions needed to convert propan-1-ol, $CH_3CH_2CH_2OH$ into

(i) $CH_3CH_2CH_2Cl$; (ii) CH_3CH_2COOH ; (iii) $CH_3CH = CH_2$.

(d) The boiling point of 1-chlorobutane, $CH_3CH_2CH_2Cl$, is 45°C while that of butan-1-ol, $CH_3CH_2CH_2OH$, is 80°C. Explain why $CH_3CH_2CH_2OH$ has a higher boiling point compared to $CH_3CH_2CH_2Cl$.

[5]

(e) Calcium hydroxide reacts with ethanoic acid to give calcium ethanoate.

(i) Write a balance equation for this reaction.

(ii) A liquid ketone **D** (Mr=58) is produced when calcium ethanoate is heated. **D** has the following composition by mass: C, 62.1%; H, 10.3%; and O, 27.6%.
What is the empirical formula of **D**? Hence deduce its identity.

(iii) Describe <u>tests</u> to confirm that **D** is a ketone.

[6]

[Total: 20]

5 (a) Describe, and explain in molecular terms, how the rate of a chemical reaction is affected by a change in temperature. [4]

(b) The acid-catalysed hydrolysis of an ester, ***X***, in water may be represented as:

$$\boldsymbol{X} + H_2O \xrightarrow{H^+} CH_3CO_2H + CH_3CH_2OH$$

To follow the rate of this reaction, the concentration of ***X*** remaining after fixed time intervals was measured. The table below shows the results of two experiments carried out using different initial concentrations of HC*l*.

time/ min	[***X***] / mol dm^{-3} with [HC*l*]=0.1 mol dm^{-3}	[***X***] / mol dm^{-3} with [HCl]=0.2 mol dm^{-3}
0	0.200	0.200
25	0.152	0.115
50	0.115	0.067
75	0.088	0.038
100	0.067	0.022
125	0.051	0.013

(i) Draw the displayed formula of ***X***.

(ii) Plot graphs of [***X***] against time for the two experiments, using the same axes.

(iii) From the graphs, what are the orders of reaction with respect to [HC*l*] and to [***X***]? Show your working clearly.

(iv) Write the rate equation, and calculate a value for the rate constant, giving its unit.

[10]

(c) The melting points of the some chlorides of the elements from period 3 are given below.

compound	formula	m.p/ °C
sodium chloride	NaCl	801
aluminium chloride	$AlCl_3$	178
silicon chloride	$SiCl_4$	–70

(i) Briefly relate the melting points of the chlorides to their structure and bonding.

(ii) State the pH of the resultant solution formed when aluminium chloride reacts with water. Write an equation which can explain for the pH value.

[6]

[Total: 20]

6 (a) The compound Na_3CrO_4 is a green solid. When mixed with dilute H_2SO_4, it disproportionates to yield $Cr^{3+}(aq)$ and $Cr_2O_7^{2-}(aq)$. The mixture produced was mixed with excess KI and the I_2 liberated required 40.0cm^3 of 0.25 mol dm^{-3} $Na_2S_2O_3(aq)$ for reaction.

(i) Write balanced half equations for each of the following changes:
- CrO_4^{3-} to Cr^{3+} and
- CrO_4^{3-} to $Cr_2O_7^{2-}$.

(ii) Use the half-equations you have written in (a)(i) to write the overall equation for the disproportionation of CrO_4^{3-} in acid.
Hence explain the term ***disproportionation***.

(iii) Given that 1 mole of $Cr_2O_7^{2-}$ liberates iodine which requires 6 moles of $S_2O_3^{2-}$ for reaction, calculate the mass of Na_3CrO_4 used in this reaction.

[7]

(b) Ammonia is manufactured from its elements in the Haber process, according to the following equation.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ mol}^{-1}$$

Le Chatelier's principle predicts that the highest equilibrium yield of ammonia is obtained at a high pressure and low temperature. However, in practice, these conditions are not used.

(i) Explain why Le Chatelier's principle predicts that a higher yield of ammonia is obtained at low temperature.

(ii) State the conditions of pressure and temperature used industrially. What factors other than Le Chatelier's principle affect this choice?

(iii) A mixture of nitrogen and hydrogen were heated to 750K in a 0.5 dm^3 sealed container. At equilibrium, the amount of gases present were as follows:
N_2 : 0.0286 mol, H_2 : 0.0455 mol, NH_3 : 0.0215 mol.
Hence, calculate the equilibrium constant, K_c, giving its units.

[7]

(c) Lime juice has a pH of 2.35.

(i) Define pH.

(ii) Calculate the molar concentration of hydrogen ions in lime juice.

A 25.0 cm^3 sample of lime juice was titrated with sodium hydroxide. It was found that the lime juice is exactly neutralised by 28.5 cm^3 of 0.10 mol dm^{-3} of the alkali.

(iii) Assuming that the lime juice contains a single acid which is monobasic, calculate the molar concentration of the acid in the lime juice.

(iv) Explain the difference between the two results you have obtained in (c)(ii) and (c)(iii).

(iv) Suggest a suitable indicator for this titration.

[6]

[Total: 20]

----- End of Paper -----