TEMASEK JUNIOR COLLEGE
Preliminary Examinations
Higher 1

CANDIDATE NAME	
CIVICS GROUP	/

CHEMISTRY

8872/02

Paper 2

17th September 2008
2 hours

Candidates answer Section A on the Question Paper.

Additional Materials: Answer Paper
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your Civics Group number and candidate name on all the work you hand in.
Write in dark blue or black pen.
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 **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	/8
	A3	/11
	A4	/11
	B	/20
	B	/20
Total		/110
Percentage		%

This document consists of **15** printed pages.

For Examiner's Use

Section A

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

1 (a) For decades, scientists were puzzled by why dinosaurs suddenly became extinct 65 million years ago. In studying core samples of rock dating back to that period, scientists found an unusual high level of iridium. This possibly came from an iridium-rich asteroid that struck the Earth's surface and the mystery to dinosaurs' extinction was solved.

Iridium exists as two naturally occurring isotopes, iridium-191 and iridium-193.

(i) Define the term *relative atomic mass*.

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(ii) The relative atomic mass of iridium is 192.2. Calculate the natural abundance, in percentage, of each isotope.

(iii) Iridium is one of the rarest metals in the Earth's crust. It is thought to exist in 2 parts per billion (ppb). Calculate the mass of iridium in 10 tonnes of Earth's crust.

[1 billion = 10^9, 1 tonne = 1000 kg]

[4]

(b) Aqua regia (a mixture of 75% nitric acid and 25% hydrochloric acid by volume) is highly corrosive. Only noble metals like iridium are inert to this solution. A 5 g sample of platinum-iridium alloy required 24.6 cm^3 of aqua regia for complete reaction. Platinum was completely oxidised to platinum(IV) ions by nitric acid and 0.5 g of metal was recovered.

(i) Find the percentage of each metal in the alloy.

(ii) The concentration of nitric acid used to make aqua regia is 5.0 mol dm^{-3}. Assuming that the reaction between the sample and aqua regia is complete, construct the balanced equation for the reaction.

[4]

(c) Man-made iridium-192 is an important radioactive isotope of iridium. It has a half-life of 74 days. The decay of a sample of iridium-192 was monitored.

(i) Calculate the original mass of the sample if the sample weighed 0.05 g after 222 days.

(ii) Suggest an application for iridium-192.

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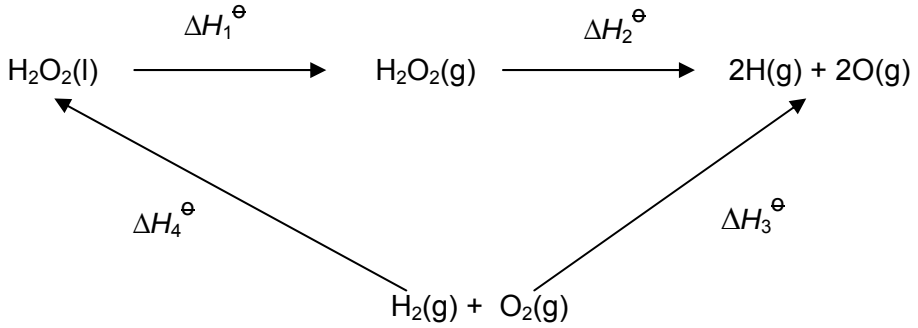
[2]

[Total: 10]

For Examiner's Use

2 (a) Liquid H_2O_2 and liquid Br_2 are two common oxidising agents used in the laboratory.

The diagram below shows an energy cycle involving liquid H_2O_2.



(i) Define the term *standard enthalpy change of reaction.*

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(ii) In the energy cycle above, name the enthalpy change represented by $\Delta H_4^{\ominus}$.

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(iii) Using the following information and data from the *Data Booklet*, calculate $\Delta H_3^{\ominus}$ and $\Delta H_4^{\ominus}$.

$\Delta H_1^{\ominus} = +51.6$ kJ mol^{-1}
$\Delta H_2^{\ominus} = +1070$ kJ mol^{-1}

[5]

(b) The boiling points of liquid H_2O_2 and liquid Br_2 are 150 ^oC and 59 ^oC respectively. Explain this difference in terms of bonding and structure.

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[3]

[Total: 8]

For Examiner's Use

3 (a) Muscalure is a pheromone secreted by common housefly. Synthetic muscalure is used to lure houseflies into fly traps.

$$CH_3(CH_2)_7CH{=}CH(CH_2)_{12}CH_3$$

muscalure

(i) Suggest why muscalure can exhibit stereoisomerism. Draw the stereoisomers.

(ii) The reaction between muscalure and aqueous bromine may be represented by the following equation:

$$CH_3(CH_2)_7CH{=}CH(CH_2)_{12}CH_3 + Br_2 + H_2O \longrightarrow CH_3(CH_2)_7\underset{\displaystyle Br}{\underset{|}{CH}}\text{-}\underset{\displaystyle OH}{\underset{|}{CH}}(CH_2)_{12}CH_3 + HBr$$

Use the bond energies given in the *Data Booklet* to calculate the enthalpy change of reaction for the above reaction.

[5]

(iii) Muscalure can be converted to compound **A**. Combustion of 15 cm^3 of gaseous **A** (M_r = 142) at elevated temperature produced 75 cm^3 of carbon dioxide, 60 cm^3 of carbon monoxide and 135 cm^3 of water vapour. Determine the formula of **A**.

[3]

(b) The enthalpy change of reaction on the hydrogenation of the three isomers, but-1-ene, cis-but-2-ene and trans-but-2-ene to form butane are given below.

Compound	ΔH / kJ mol^{-1}
but-1-ene	-127
cis-but-2-ene	-120
trans-but-2-ene	-115

(i) Using the above information, arrange the three alkenes in increasing order of stability.

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(ii) Explain your answer in part **(i)**.

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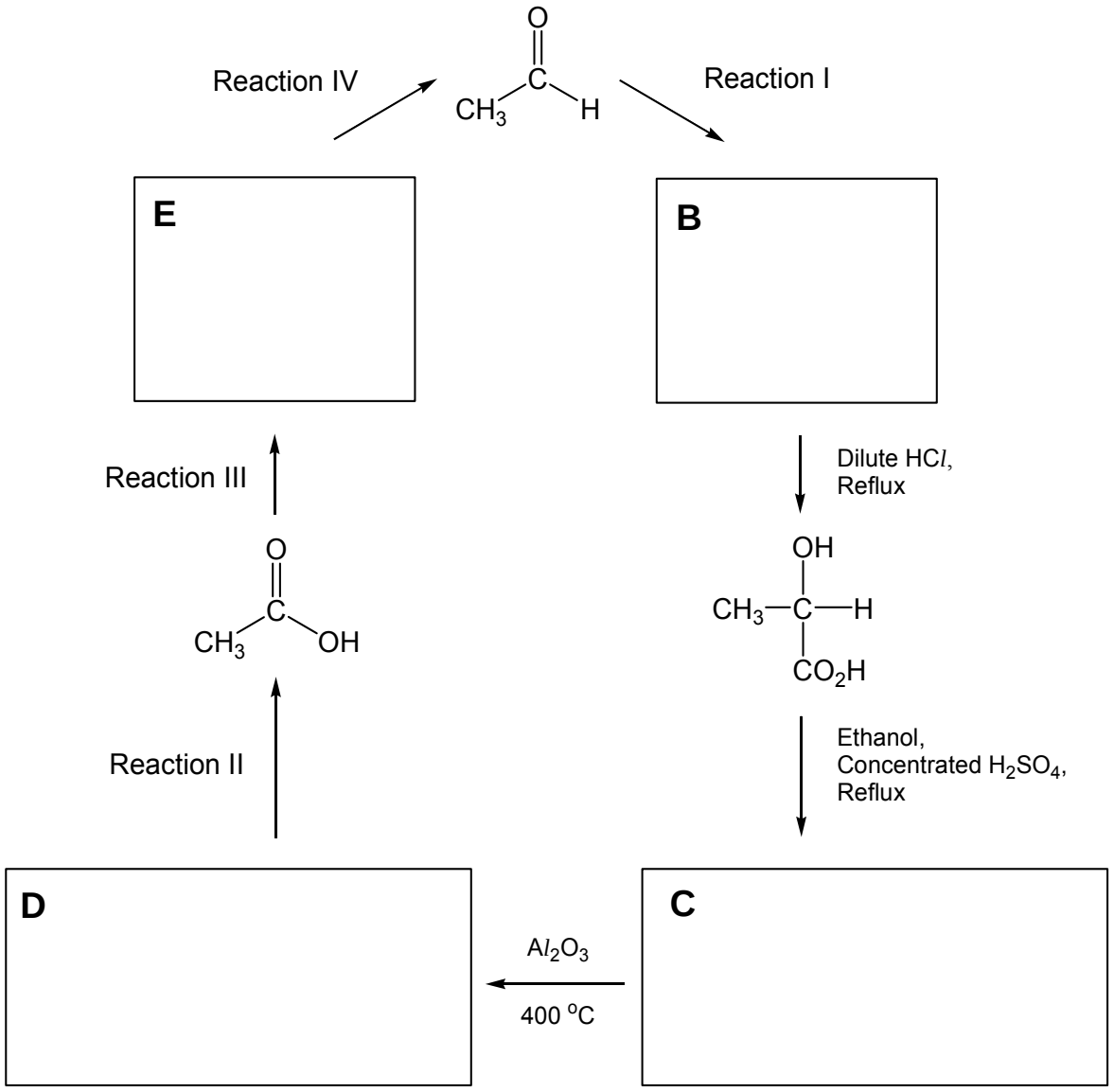
[3]

[Total: 11]

For Examiner's Use

4 (a) Ethanal is a flammable liquid with a fruity smell. It occurs naturally in ripe fruit, coffee and fresh bread. A synthetic route involving ethanal is shown below.



(i) Draw the structural formulae of compounds **B**, **C**, **D** and **E** in the boxes above.

(ii) Suggest reagents and conditions for

reaction I, ...

reaction II, ...

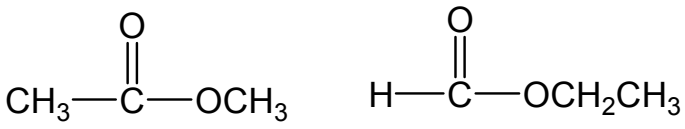
reaction III, ...

reaction IV. .....

[8]

For Examiner's Use

(b) Suggest how the following compounds can be distinguished from each other. State the reagents and conditions you would use and the observations you would make with each compound.



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[3]

[Total: 11]

Section B

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

5 (a) Describe, and explain in molecular terms, how the rate of a chemical reaction is affected by a change in temperature. [3]

(b) On December 14, 2007, it was announced in an article by the Los Angeles Department of Water and Power that a number of reservoirs were going to be drained due to bromate(V) ion contamination. Bromate(V) in drinking water is undesirable because it is a suspected human carcinogen.

A research student conducted an experiment involving bromate(V) ion according to the following unbalanced equation:

$$BrO_3^-(aq) + Br^-(aq) + H^+(aq) \longrightarrow Br_2(l) + H_2O(l)$$

(i) Balance this equation.

(ii) Draw a diagram to illustrate the shape of bromate(V) ion. Name the shape. [3]

The student attempted to follow the rate of the reaction by measuring concentration of remaining bromate(V) ion after fixed time intervals. He also ensured that the H^+ ions do not interfere with the reaction.

Two experiments were carried out, starting with different concentrations of bromide ions. The following results were obtained.

time/min	Experiment 1 with $[Br^-] = 0.5$ mol dm^{-3}	Experiment 2 with $[Br^-] = 1.0$ mol dm^{-3}
	$[BrO_3^-]$ / mol dm^{-3}	$[BrO_3^-]$ / mol dm^{-3}
0	0.050	0.050
15	0.040	0.032
30	0.032	0.021
45	0.026	0.013
60	0.021	0.009
75	0.017	0.006
90	0.014	0.004

(iii) Using the same axes, plot graphs of $[BrO_3^-]$ against time for the two experiments.

(iv) Use your graphs to determine the following:

I Use the half-life method to deduce the order of reaction with respect to the bromate(V) ion.

II Use the initial rates method to deduce the order of reaction with respect to the bromide ion.

Hence, construct a rate equation for the reaction.

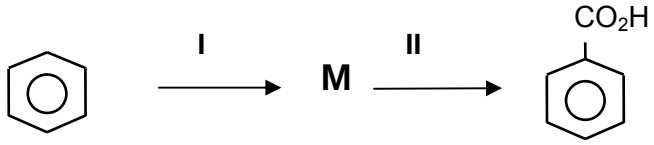
(v) Calculate a value for the rate constant, giving the units.

(vi) Explain how the research student ensured that the H^+ ions do not interfere with the reaction. [8]

(c) In an analysis of a sample of the reservoir water, traces of benzene, pentane and 2-chloropropane were found to be present.

(i) Describe a simple chemical test which would distinguish between pentane and 2-chloropropane. State what you would observe for each compound.

(ii) The following route is proposed to synthesize benzoic acid using benzene:



Suggest reagents and conditions for reactions I and II, and draw the structural formula of the intermediate **M**. [6]

[Total: 20]

6 (a) The decomposition of gaseous phosphorus(V) chloride is endothermic.

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

At a certain temperature, a 2 dm^3 sealed vessel initially contained only 0.596 moles of gaseous PCl_3 and 0.0174 moles of gaseous PCl_5. After the system had reached equilibrium, 4.00×10^{-3} moles of chlorine gas was found in the vessel.

(i) Write an expression for the K_c of this reaction.

(ii) Calculate the equilibrium concentrations of all species and the value for K_c, giving its units.

(iii) State the *Le Chatelier's principle*.

(iv) Predict, with reasoning, how the position of equilibrium might change if

the temperature of the vessel was decreased
an inert gas was added to the reaction mixture in the flask. [9]

(b) Phosphorus(V) chloride undergoes complete hydrolysis in water to give phosphoric acid. Phosphoric acid is a triprotic acid that dissociates in the following steps:

$H_3PO_4(aq) \rightleftharpoons H_2PO_4^-(aq) + H^+(aq)$ $\quad K_{a_1} = 7.5 \times 10^{-3}$ mol dm^{-3}
$H_2PO_4^-(aq) \rightleftharpoons HPO_4^{2-}(aq) + H^+(aq)$ $\quad K_{a_2} = 6.2 \times 10^{-8}$ mol dm^{-3}
$HPO_4^{2-}(aq) \rightleftharpoons PO_4^{3-}(aq) + H^+(aq)$ $\quad K_{a_3} = 4.8 \times 10^{-13}$ mol dm^{-3}

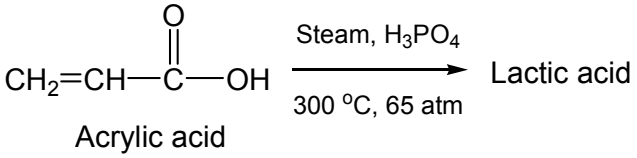
(i) Explain why phosphoric acid is a stronger acid than the dihydrogen phosphate ion, $H_2PO_4^-$ (i.e $K_{a_1} > K_{a_2}$).

(ii) Draw a diagram to illlustrate the shape of the phosphate ion, PO_4^{3-}.

(iii) 25 cm^3 of 0.20 mol dm^{-3} of phosphoric acid was reacted with 30 cm^3 of 0.60 mol dm^{-3} of aqueous sodium hydroxide. Calculate the pH of the reaction mixture. [5]

(c) The phosphate buffer system plays a major role in intracellular fluids. At the prevailing pH values in most biological systems, $H_2PO_4^-$ and HPO_4^{2-} are the main species present. With the aid of two equations, explain how a solution of $H_2PO_4^-$ and HPO_4^{2-} can act as a buffer. [2]

(d) Phosphoric acid can be used to catalyse the conversion of acrylic acid to lactic acid. The production of lactic acid in the body during exercise is believed to cause muscle fatigue.



Acrylic acid

(i) Draw the structural formula of lactic acid.

Acrylic acid can also be converted to propanoic acid, 2-chloropropanoic acid and propan-1-ol.

(ii) Arrange propanoic acid, 2-chloropropanoic acid and propan-1-ol in increasing order of acid strength. Explain your answers. [4]

[Total: 20]

7 (a) The oxides of elements have many industrial uses. For instance, the oxides of sodium and silicon are used in the manufacture of glass and the oxide of sulphur is used in winemaking. Another oxide, gallium(III) oxide, is commonly used in the manufacture of electronic devices.

(i) The oxides of sodium, silicon and sulphur differ in their reactions with water.

Describe these reactions, relating them to the structure and bonding in each oxide. Write equations where appropriate.

(ii) By means of balanced equation(s), indicate whether gallium(III) oxide reacts with aqueous NaOH and dilute HC*l*. [7]

(b) One isotope of potassium, ^{40}K, decays to form argon, ^{40}Ar, which is stable. In the process, a particle **V** is given out.

(i) Define the term *isotopes*.

(ii) State the number of proton(s) and neutron(s) in particle **V**. [3]

(c) In an analysis, a compound **W** is found to contain 72.4% carbon, 11.8% hydrogen and 15.8% oxygen by mass. The relative molecular mass of **W** is 100.

When **W** is heated with acidified potassium manganate(VII), a compound **X**, $C_4H_6O_3$, is produced together with ethanoic acid.

When **X** is warmed with an alkaline solution of iodine, it yielded a yellow precipitate and a solution which, when treated with dilute sulphuric acid, gave a compound **Y**.

Y can also be obtained from the acid hydrolysis of NC – CH_2 – CN.

On heating with concentrated sulphuric acid, 2 moles of **X** reacted with 1 mole of ethane-1,2-diol to give a compound **Z**.

Identify the structures of compounds **W, X, Y** and **Z** and explain the chemistry of the reactions described. [10]

[Total: 20]