Class	Reg Number

Candidate Name ___________________________

MERIDIAN JUNIOR COLLEGE
Preliminary Exam
Higher 2

H2 Chemistry 9647/3

Paper 3 Free Response

18 Sep 2012

2 hours

Additional Materials: Data Booklet
Writing paper

INSTRUCTIONS TO CANDIDATES

Write your name, class and register number in the spaces provided at the top of this page.

Answer 4 out of 5 questions in this paper.

Begin each question on a fresh page of writing paper.

Fasten the writing papers behind the given **Cover Page for Questions 1 & 2** and **Cover Page for Questions 3, 4 & 5** respectively.

Hand in Questions 1 & 2 and 3, 4 & 5 separately.

You are advised to spend about 30 min per question only.

INFORMATION FOR CANDIDATES

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

You are reminded of the need for good English and clear presentation in your answers.

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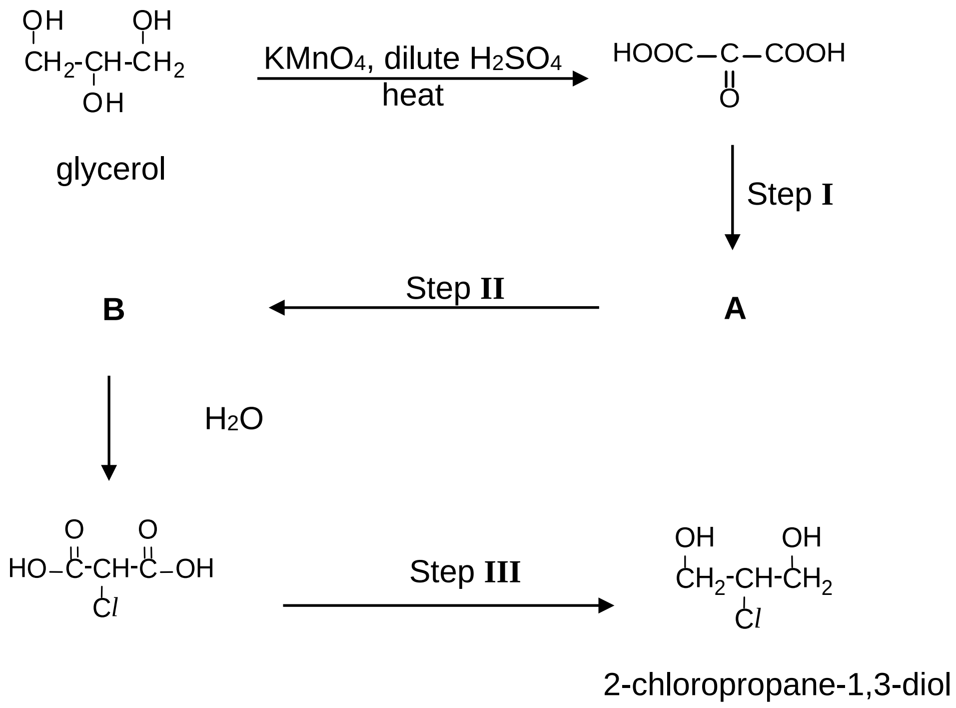
Answer any 4 out of 5 questions in this paper.
*Begin each question on a **fresh sheet** of writing paper.*

1 Sugars, or saccharides, are the most abundant bio-molecules found on the planet and play many important biological roles. A simple sugar, a derivative of a straight chain polyhydroxyl alcohol and glycerol, is considered to be the parent of all sugars.

(a) 2-chloropropane-1,3-diol can be synthesised from glycerol via the reaction scheme below.



Suggest reagents and conditions for steps **I** to **III**, and draw the structural formula of intermediates **A** and **B**.

[5]

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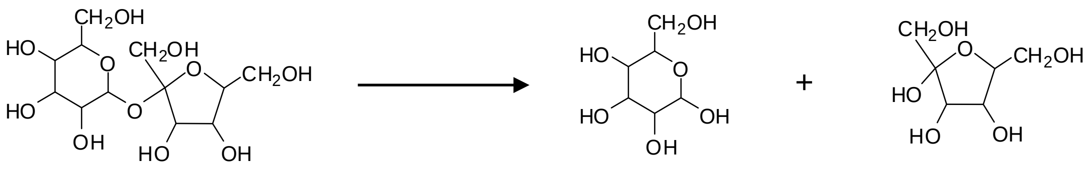
(b) Glucose, an important simple sugar or monosaccharide, is required by the cells in our body as a source of energy and metabolic intermediate.

A common source of glucose is sucrose or table sugar. In humans and other mammals, sucrose is broken down into its constituent monosaccharides, glucose and fructose as shown below.



sucrose glucose fructose

(i) Name the functional group, other than ether (R-O-R), present in sucrose.

(ii) Suggest the type of reaction undergone by sucrose.

[2]

(c) Glucose undergoes complete combustion to form carbon dioxide and water.

(i) Write a balanced equation for the complete combustion of glucose.

(ii) The standard enthalpy change of formation of CO_2, H_2O and glucose is -394 kJ mol^{-1}, -286 kJ mol^{-1} and -1275 kJ mol^{-1} respectively.

Use your answer in **(c)(i)** and the data given to calculate the energy released when 9.0 g of glucose undergoes complete combustion.

(iii) In a calometric experiment, 9.0 g of glucose was burnt completely and the energy released raised the temperature of 650 cm^3 of water by 44^{o}C.

Calculate the energy released by the combustion of 9.0 g of glucose in the experiment.

(iv) Suggest a reason for the discrepancy between the answers in **(c)(ii)** and **(c)(iii).**

[5]

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(d) Group II nitrates and sugars undergo decomposition when heated.

(i) Write an equation for the thermal decomposition of Group II nitrates.

(ii) Suggest why the numerical value of the entropy change is very similar for the decomposition reaction of all the Group II nitrates.

(iii) Predict, with reasoning, whether magnesium nitrate or barium nitrate has a higher decomposition temperature.

[4]

(e) Chlorophyll is an extremely important bio-molecule which allows plants to absorb energy from light. It consists of a chlorin ring with a magnesium ion, Mg^{2+}, at the centre of the ring.

With the aid of an energy cycle, calculate the enthalpy change of hydration of Mg^{2+} using the following data and appropriate data from the *Data Booklet*.

enthalpy change of solution of $MgCl_2$	= - 153 kJ mol^{-1}
enthalpy change of hydration of Cl^-	= - 362 kJ mol^{-1}
enthalpy change of formation of $MgCl_2$	= - 642 kJ mol^{-1}
enthalpy change of atomization of Mg	= + 148 kJ mol^{-1}
first electron affinity of Cl	= - 364 kJ mol^{-1}

[4]
[Total: 20]

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2(a) Halogens react readily with hydrogen.

$$X_2(g) + H_2(g) \quad ® \quad 2HX(g) \qquad (\text{where } X = \text{C}l\text{, Br or I})$$

(i) Describe how you could carry out this reaction using chlorine.

(ii) Describe **two** observations you would make if this reaction was carried out with bromine.

(iii) Describe and explain the trend observed in the reactions of the elements chlorine, bromine and iodine with hydrogen.

[6]

(b) Some halogens also react readily with alkanes. Consider the following sequence of reactions.

$$\underset{\text{alkane } \mathbf{W}}{C_6H_{14}} \xrightarrow{\textit{Reaction } \mathbf{1}} C_6H_{13}X \xrightarrow{\textit{Reaction } \mathbf{2}} C_6H_{13}OH$$

(i) State the reagent and conditions needed for ***reaction 1*** when *X* is bromine, Br.

(ii) Use bond energy data from the *Data Booklet* to calculate the $\Delta H^\ominus$ of ***reaction 1*** when *X* is iodine, I.

(iii) Hence, suggest why it is not possible to synthesise iodoalkane by ***reaction 1***.

(iv) In another separate experiment using ***reaction 1*****,** alkane **W**, C_6H_{14}, produced **only two** isomeric monobromo compounds **Y** and **Z**, with the molecular formula $C_6H_{13}Br$. Compound **Z** is chiral.

Suggest the structures of **W**, **Y** and **Z**.

[6]

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(c) Both isomers **Y** and **Z** with formula $C_6H_{13}Br$ can undergo ***reaction 2*** with aqueous sodium hydroxide solution to form alcohols. When the reaction of one of these isomers with aqueous sodium hydroxide was investigated, the following kinetic data was obtained.

Experiment	**Initial [$C_6H_{13}Br$] / mol dm^{-3}**	**Initial [OH^-] / mol dm^{-3}**	**Initial rate of reaction / mol dm^{-3} min^{-1}**
1	1.30	2.60	13.0
2	2.60	1.30	26.0
3	3.90	2.60	39.0
4	7.80	5.20	78.0

(i) Use these data to deduce the order of reaction with respect to each of the reagents, showing how you arrive at your answers. Hence, write the rate equation for the above reaction.

(ii) Suggest which isomer **Y** or **Z** was being investigated in the above reaction and explain your choice.

(iii) Hence, using the isomer you have suggested in **(c)(ii)**, describe a mechanism that is consistent with your rate equation, and indicate which step in the mechanism is the rate determining step.

(iv) Draw a labeled energy profile diagram of the mechanism you described in **(c)(iii)**.

[8]
[Total: 20]

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3(a) Iron metal has traditionally been extracted from its ore **using a Blast furnace**. The process uses coke (carbon) and haematite (Fe_2O_3) in three stages, whereby

- coke is first oxidised by air to form carbon dioxide;
- the carbon dioxide formed further reacts with more coke to form carbon monoxide;
- the haematite is reduced to obtain the iron metal

New research proposes that iron could be recovered **via electrolysis**. This involves passing current via inert platinum electrodes into a mixture of molten Fe_2O_3. This new process is thought to be more advantageous than using the current Blast furnace method.

(i) Draw a diagram to illustrate the electrolysis set-up, showing clearly the polarity of the electrodes and the species attracted to and formed at each electrode.

(ii) Give the equations, including state symbols, for the reactions occurring at each electrode.

(iii) An initial pilot production plant using the new method yields 5 kg of iron per day. Calculate the current to be supplied per day if the pilot plant runs continuously for 24 hours each day.

(iv) Construct the equations for the reactions occurring at each stage of the Blast furnace extraction of iron.

(v) Suggest an advantage of the new electrolysis method over the Blast furnace method.

[8]

(b) Solutions of iron(II) compounds are commonly prepared in the laboratory.

(i) By selecting two appropriate half-equations from the *Data Booklet*, explain why iron(II) solutions are normally made up and stored in the presence of acids instead of bases.

(ii) With the aid of suitable equations, explain why iron(II) solutions can catalyse the reaction involving iodide ions with peroxodisulfate(VI) ions.

$$2I^- (aq) + S_2O_8^{2-} (aq) \rightarrow I_2 (aq) + 2SO_4^{2-} (aq)$$

[5]

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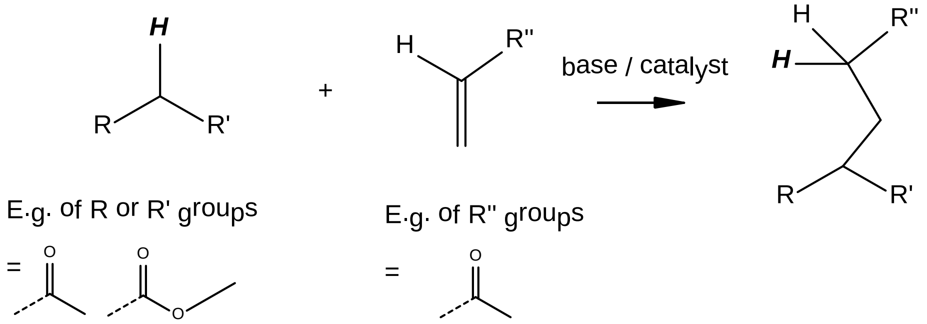
(c) Iron compounds can be used to catalyse a number of organic reactions. One such organic reaction is the Michael reaction as shown below.

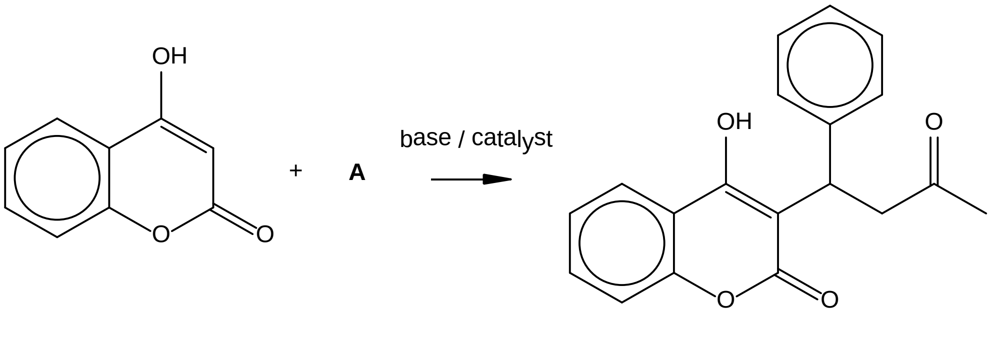


The reaction can also be carried out using sodium ethoxide ($CH_3CH_2O^-Na^+$) as a catalyst, whereby the labelled hydrogen ***H*** reacts with the ethoxide ion as a proton and is eventually transferred to its new position on the product.

(i) Explain how the ethoxide ion is able to remove the proton in the Michael reaction.

(ii) State the type of reaction which occurs in the Michael reaction.

The Michael reaction can be used to synthesise a useful blood anticoagulant known as *Warfarin.* The synthesis of *Warfarin* can give rise to two possible isomers.



Warfarin

(iii) Suggest the structure of compound **A** used to form *Warfarin*.

(iv) State the type of isomerism present in *Warfarin* and sketch the structures of these two isomers. [You may use R to represent a part of the molecule in your answer]

(v) Draw the structure of the product formed when 2,4-DNPH is reacted with *Warfarin*.

[7]
[Total: 20]

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4 Oxygen reacts with various Period III elements to produce compounds of numerous uses. Examples are Al_2O_3 which is often used as a refractory material and chlorine oxides which act as oxidising agents used in water treatments and in bleaching.

(a) Element **X** forms a white oxide that is soluble in cold water. Its chloride dissolves in water to form a neutral solution.

Element **Y** forms two oxides. 0.09 mol of one of the two oxides produces 12.3 g of white precipitate when shaken with excess calcium hydroxide solution. A solution containing 1 mol of the oxide of element **Y** forms a neutral solution when the same amount of the oxide of element **X** is added to it.

Given that **X** and **Y** are Period III elements, identify the element **X** and the oxide of **Y** in the above reactions. Explain the observations with the help of relevant equations.

[4]

(b) When a sample of an oxide of chlorine, Cl_mO_n, was vapourised in a suitable apparatus at 250 °C and 101 kPa, the density of the gas was found to be 1.60 g dm^{-3}.

(i) Calculate the molar mass of the gas and hence suggest the value of **m** and **n**.

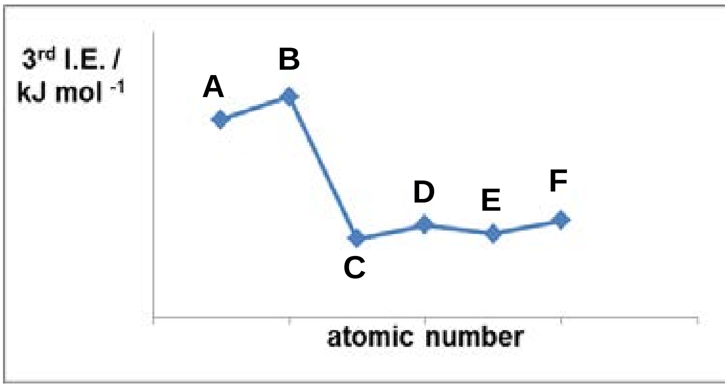
(ii) Explain why the molar mass obtained in **(b)(i)** is different from the theoretical value.

[4]

(c) **A** to **F** are consecutive elements having atomic numbers between 10 to 20.

(i) Write an equation that represents the third ionisation energy of aluminium.

(ii) From the graph below, identify which element, **A** to **F,** is aluminium. Explain your answer.



[3]

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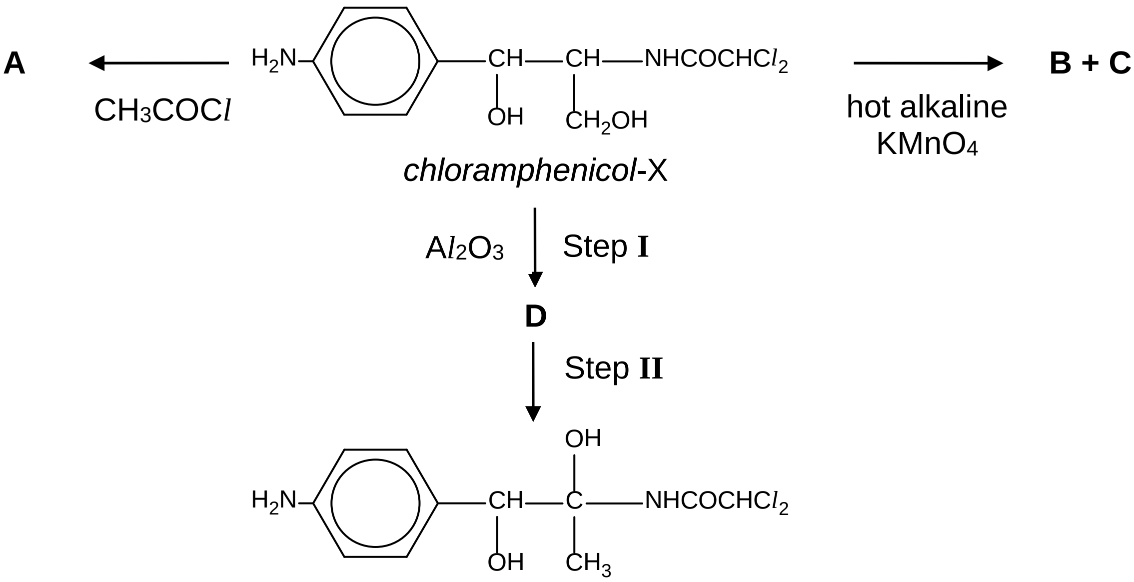
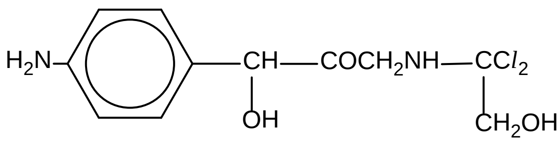
(d) Other than its use as a refractory material, Al_2O_3 is also used in chemical reactions involving organic compounds. In the reaction scheme below, Al_2O_3 is used to dehydrate *chloramphenicol*-X to form compound **D**.



(i) Identify the lettered compounds **A** to **D**.

(ii) Suggest the reagent and condition used in step **II.** State the type of reaction occurring in step **II**.

(iii) Describe a simple chemical test to distinguish between *chloramphenicol*-X and its isomer shown below.



[9]
[Total: 20]

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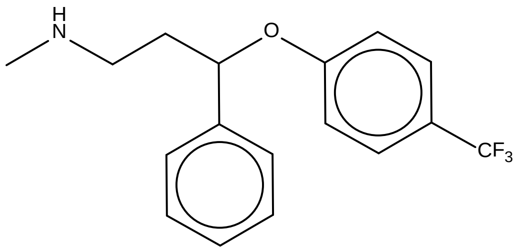
5 *Fluoxetine* is an anti-depressant drug or mood elevator commonly used to treat depression and other mental illness like obsessive compulsive behaviour.

The structure of *Fluoxetine* is shown below:



Fluoxetine

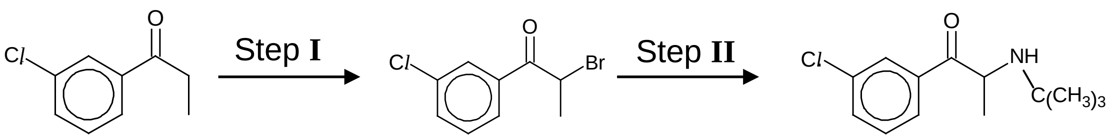
(a) **(i)** Draw a diagram to show how hydrogen bonding occurs between one molecule of *Fluoxetine* and two molecules of water.

(ii) Suggest why *Fluoxetine* is insoluble in water despite the formation of hydrogen bonding between *Fluoxetine* and water molecules.

(iii) *Fluoxetine* is manufactured and merchandised as *Fluoxetine* hydrochloride. Explain, in terms of structure and bonding, why this is so.

[5]

(b) *Bupropion* is another type of anti-depressant. It is synthesised from 3-chloropropiophenone as shown in the pathway below.



3-chloropropiophenone intermediate **X** *Bupropion*

(i) State the type of reaction that occurs in step **I.**

(ii) Suggest the reagents and conditions for step **II**.

(iii) Draw the structure of the product obtained by heating intermediate **X** with aqueous potassium hydroxide.

[3]

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(c) Compound **A**, $C_{11}H_{15}NO_3$, has potential to treat certain mental disorders. Compound **A** reacts with aqueous bromine to form compound **B**, $C_{11}H_{13}NO_3Br_2$. 1 mole of compound **A** reacts with 2 mole of aqueous sodium hydroxide at room temperature. No decolourisation is observed upon heating compound **A** with acidified potassium manganate(VII). Compound **A** reacts with iodomethane to form compound **C**, $C_{12}H_{18}NO_3I$, which yields a yellow precipitate with aqueous silver nitrate at room temperature.

Suggest the structure of each lettered compound and explain the reactions involved.

[8]

(d) In some cases of mental illness, lithium ion, Li^+, can also be administered in the form of lithium salt as a mood-stabilizing drug.

(i) Explain why Li has the lowest first ionisation energy among the Period 2 elements.

(ii) All Group I halides dissolve in water to give neutral solutions containing hydrated ions.

Suggest why lithium forms $Li(H_2O)_4^+$ ions, whereas the other Group I halides form mainly $M(H_2O)_6^+$ ions.

[4]
[Total: 20]

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