

Class Reg Number

Candidate Name _____

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**Meridian Junior College
2009 JC 2 Preliminary Examination
H2 Chemistry 9746**

22 September 2009

1 hr 30 min

**Paper 2
STRUCTURED QUESTIONS**

Additional Materials
Data Booklet

INSTRUCTION TO CANDIDATES

Write your name, class and register number in the spaces provided at the top of this page.
Write in dark blue or black ink.
You may use a soft pencil for any diagrams or graphs.
You are reminded on the need for good English and clear presentation of your answers.

INFORMATION FOR CANDIDATES

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

FOR EXAMINER'S USE	
Q1	/ 8
Q2	/ 8
Q3	/ 11
Q4	/ 11
Q5	/ 12
Q6	/ 10
Total	/ 60

This question paper consists of 18 printed pages

Answer all the questions in the space provided

- 1** Early Periodic Tables, such as that devised by Mendeleev, listed the then known elements in order of their relative atomic mass.

			Ti = 50	Zr = 90	? = 180
			V = 51	Nb = 94	Ta = 182
			Cr = 52	Mo = 96	W = 186
			Mn = 55	Rh = 104.4	Pt = 197.4
			Fe = 56	Ru = 104.4	Ir = 198
			Ni = Co = 59	Pd = 106.6	Os = 199
H = 1			Cu = 63.4	Ag = 108	Hg = 200
	Be = 9.4	Mg = 24	Zn = 65.2	Cd = 112	
	B = 11	Al = 27.4	? = 68	Ur = 116	Au = 197?
	C = 12	Si = 28	? = 70	Sn = 118	
	N = 14	P = 31	As = 75	Sb = 122	Bi = 210?
	O = 16	S = 32	Se = 79.4	Te = 128?	
	F = 19	Cl = 35.5	Br = 80	I = 127	
Li = 7	Na = 23	K = 39	Rb = 85.4	Cs = 133	Ti = 204
		Ca = 40	Sr = 87.6	Ba = 137	Pb = 207
		? = 45	Ce = 92		
		?Er = 56	La = 94		
		?Yt = 60	Di = 95		
		?In = 75.6	Th = 118?		

- (a)** **(i)** When Mendeleev created the Periodic Table, there were uncertainties regarding the relative atomic mass of tellurium, Te. It is now known that there are eight isotopes of tellurium.

isotope	percentage abundance	isotopic mass x percentage abundance
tellurium-120	0.09	11
tellurium-122	2.46	300
tellurium-123	0.87	107
tellurium-124	4.61	572
tellurium-125	6.99	874
tellurium-126	18.71	2357
tellurium-128	31.79	
tellurium-130		

Complete the above table and give your answers to **two** decimal places.

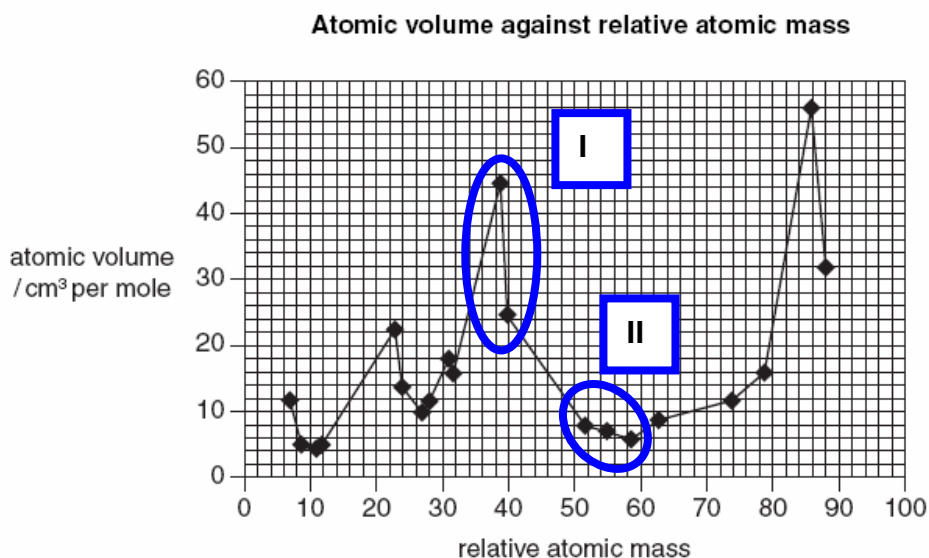
Hence, calculate the relative atomic mass of tellurium to **five** significant figures.

- (ii) TeO_2 resembles aluminium oxide in its acid-base properties. TeO_2 , SiO_2 and P_4O_{10} cannot be distinguished based on their physical appearance.

If a sample of one of the oxides was provided as a fine powder, describe the reactions you could carry out on the powder to determine which of the three oxides it was. Include all relevant equations in your answer.

[5]

- (b) Another chemist looking for patterns in the properties of the elements around the time of Mendeleev was Julius Lothar Meyer. Lothar Meyer looked at how the atomic volume of an element varies with its relative atomic mass. A simplified version of the graph he plotted is shown below.



There are 2 circled regions on the graph. Explain why there is only a slight decrease in atomic volume between the elements in region II compared to region I.

[3]

[Total: 8]

- 2 'Hard' water is water that has high mineral content such as calcium ions.

A common washing-up liquid contains sodium dodecylbenzenesulphonate, $\text{C}_{18}\text{H}_{29}\text{SO}_3\text{Na}$ [$M_r = 348$]. In 'hard' water, it is ineffective as a detergent because it reacts with calcium ions to give a precipitate. The solubility product, K_{sp} , for $(\text{C}_{18}\text{H}_{29}\text{SO}_3)_2\text{Ca}$ (s) is $1.20 \times 10^{-17} \text{ mol}^3 \text{ dm}^{-9}$.

The washing-up liquid contains 17.4% of sodium dodecylbenzenesulphonate by mass. In a factory production, 0.500 dm^3 of 0.102 g dm^{-3} of the washing-up liquid was accidentally mixed with 0.200 dm^3 of 'hard' water.

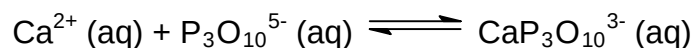
A typical sample of 'hard' water has a concentration of calcium ions of $2.50 \times 10^{-4} \text{ mol dm}^{-3}$.

- (a) Determine whether a precipitate is formed when the common washing-up liquid was accidentally mixed with 0.200 dm^3 of 'hard' water.

[2]

- (b)** In order for the detergent to be used in 'hard' water, sodium tripolyphosphate, $\text{Na}_5\text{P}_3\text{O}_{10}$, is added as a water softening agent.

The sodium tripolyphosphate 'softens' water by complexing with calcium ions. The complexation reaction is as follows:



For this reaction with calcium ions, the equilibrium constant is $7.7 \times 10^8 \text{ mol}^{-1} \text{ dm}^3$.

- (i)** Write the K_c expression for the reaction.
- (ii)** Hence, calculate the concentration of tripolyphosphate ions required to reduce the calcium ion concentration in a typical sample of "hard water" to $1.0 \times 10^{-6} \text{ mol dm}^{-3}$.

[3]

- (c) 'Hard' water also contains magnesium ions which can form a precipitate with the detergent. For example, magnesium ions form magnesium iodide, MgI_2 , in the presence of aqueous potassium iodide.

- (i) The lattice energy of MgI_2 is $-2327 \text{ kJ mol}^{-1}$ while the values of the enthalpy change of hydration are listed below:

Ions	$\Delta H_{\text{hyd}} / \text{kJ mol}^{-1}$
Mg^{2+}	-1920
I^-	-295

Calculate the enthalpy change of solution of magnesium iodide.

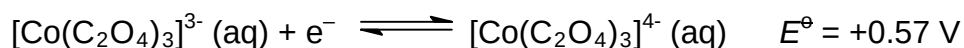
- (ii) By using your answer from (c)(i), and given the entropy change of solution of magnesium iodide is positive, predict whether magnesium iodide is soluble in water at room temperature and pressure. Give your reasoning.

[3]

[Total: 8]

- 3** Cobalt is a bluish-white element that can form various cobalt compounds with ligands such as ethylenediamine, $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$, and ethanedioate, $\text{C}_2\text{O}_4^{2-}$. Ethylenediamine is commonly expressed with the short form “*en*”.
- (a)** Passing air through an aqueous solution containing CoCl_3 , *en* and HCl produces a green complex cation, $[\text{Co}(\text{en})_2\text{Cl}_2]^+$. Another complex, $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$ is obtained on passing air through an aqueous solution of CoCl_3 and $\text{C}_2\text{O}_4^{2-}$.
- (i)** State the coordination number of Co in $[\text{Co}(\text{en})_2\text{Cl}_2]^+$.
- (ii)** Explain why transition element complexes such as $[\text{Co}(\text{en})_2\text{Cl}_2]^+$ are coloured.

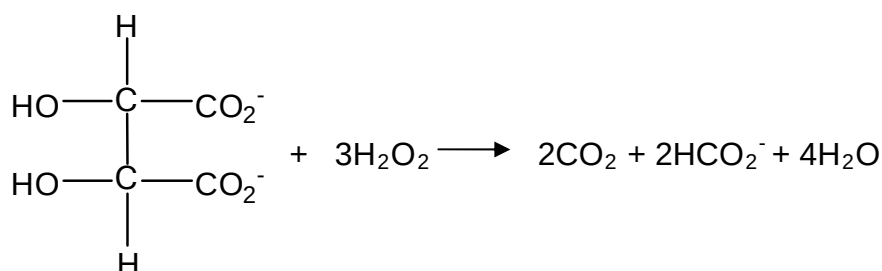
- (iii) The standard electrode potential of the $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-} / [\text{Co}(\text{C}_2\text{O}_4)_3]^{4-}$ is given below.



Draw a fully labelled diagram to show how the standard electrode potential of the $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}(\text{aq}) / [\text{Co}(\text{C}_2\text{O}_4)_3]^{4-}(\text{aq})$ system can be measured.

- (iv) In general, the presence of ethanedioate ions, $\text{C}_2\text{O}_4^{2-}$, significantly decreases the oxidising ability of Co(III) . Explain this effect by using the information in (a)(iii) and relevant data from the *Data Booklet*.

- (b) Other than being used as silica gel, cobalt (II) chloride can also be used as a homogeneous catalyst for the reaction of 2,3-dihydroxybutanedioate ions and hydrogen peroxide to form carbon dioxide, methanoate ions and water.



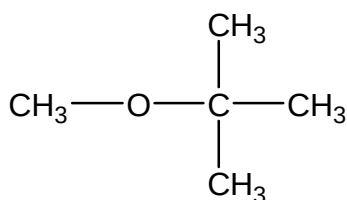
Suggest equations for a plausible mechanism for the catalysis of the above reaction using Co^{2+} as the catalyst.

[2]

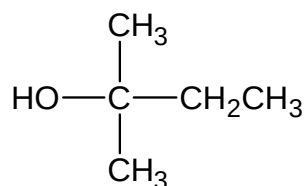
[Total: 11]

- 4 *MTBE* as well as its isomer *MTBE A* is added to car petrol as oxygenates. There has been concern over the leakage of *MTBE* and *MTBE A* into water supplies, mainly because of the foul taste it gives to water supplies.

In the manufacture of fuel for industries, liquid *MTBE A* is added as a solvent to petroleum to reduce pollution.



MTBE



MTBE A

- (a) What is meant by the *standard enthalpy change of formation of MTBE A*?

[1]

- (b) Using relevant information from the *Data Booklet* and the data provided, obtain a value for the average bond energy for the O–H bond in *MTBE A*, by means of an appropriate energy cycle.

Data provided: $\Delta H_{\text{at}}(\text{C}) = +715 \text{ kJ mol}^{-1}$,
 $\Delta H_{\text{f}}(\text{MTBE A}) = -380 \text{ kJ mol}^{-1}$
 $\Delta H_{\text{vap}}(\text{MTBE A}) = +50.7 \text{ kJ mol}^{-1}$

[3]

- (c) Suggest a reason for the difference in the O–H bond energy obtained in (b) from the value given in the *Data Booklet*.

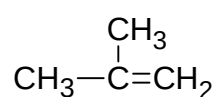
[1]

- (d) In a combustion reaction of industrial fuel, *MTBE* is completely combusted in an engine cylinder at 175°C which had an internal volume of 1055 dm^3 .
- (i) Determine the pressure (in pascals) exerted by the carbon dioxide emitted by the combustion of 4 kg of *MTBE* fuel.

- (ii) In fact, the pressure inside the engine cylinder was found to be slightly lower than the value calculated in **d(i)**. Explain the discrepancy in the two values.

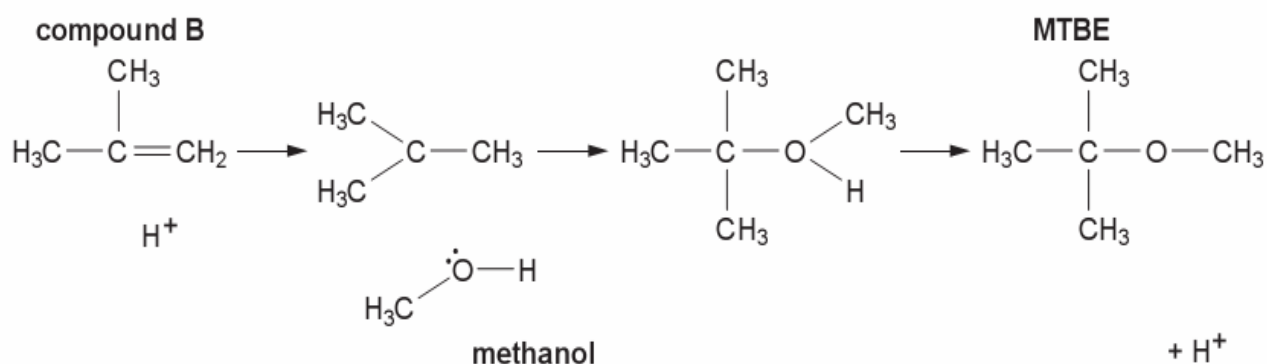
[4]

- (e) MTBE can be made by reacting compound **B** with methanol in the presence of an acid catalyst.



compound **B**

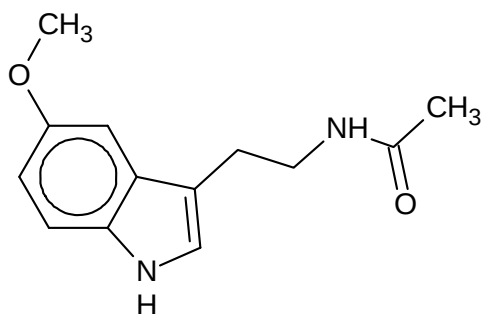
Complete the mechanism below by inserting “curly arrows” to show the movement of pairs of electrons and by inserting the appropriate charges.



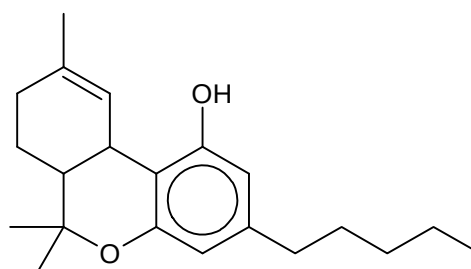
[2]

[Total: 11]

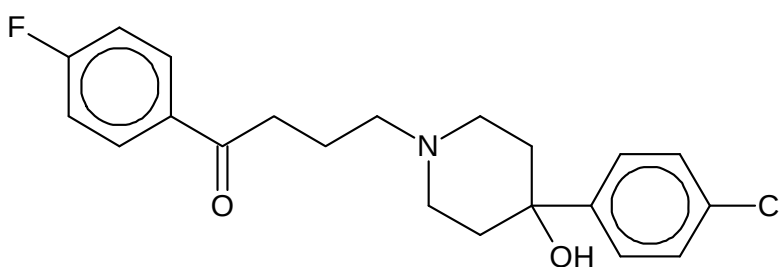
- 5 *Melatonin* is a naturally occurring hormone found in animals, *THC* is a drug obtained from the cannabis plant, and *haloperidol* is an antipsychotic drug.



melatonin



THC



haloperidol

- (a) Drug smugglers extract crude *THC* from cannabis leaves by using benzene as a solvent. Explain the rationale behind this extraction.

[1]

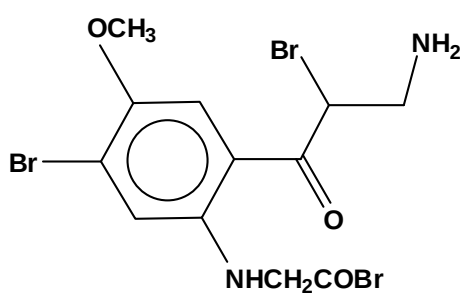
- (b) All three organic molecules share similar reactions with some reagents only.
- State one reagent that will react with both *melatonin* and *haloperidol* and **not** with *THC*.
 - State one reagent and the required condition that will react with both *melatonin* and *THC* but **not** with *haloperidol*.
 - State one reagent, other than MnO_4^- ions, and the conditions required that will react with all three compounds.

[3]

- (c) *Melatonin* can be made through the reaction between two organic compounds in the laboratory. Suggest the structural formulae of these two compounds.

[1]

- (d) *Melatonin* can undergo a series of reactions to obtain compound X.



Compound X

Explain the different reactivities of the three bromine atoms in compound X.

[3]

- (e) Describe a chemical test that would allow you to distinguish between the following pairs of compounds. The distinguishing may rely on a preliminary breaking-up of the compounds, and subsequent testing of the reaction products.

In each test, you must identify the **second organic compound** positively. State only the observations for the positive test.

(i) *THC* and *melatonin*

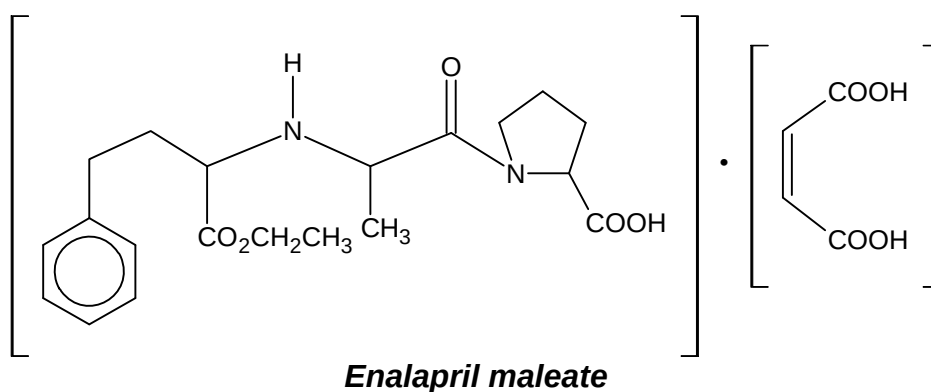
(ii) *THC* and *haloperidol*

[4]

[Total: 12]

- 6 *Enalapril maleate* is widely used in the treatment of hypertension and chronic heart diseases. When *Enalapril maleate* is consumed, the body hydrolyses the molecule into the active form, *Enalaprilate*, which suppresses the activity of enzymes that trigger high blood pressure.

Enalapril maleate is sold as tablets. Some additional information on *Enalapril maleate* and *Enalaprilate* are given below.

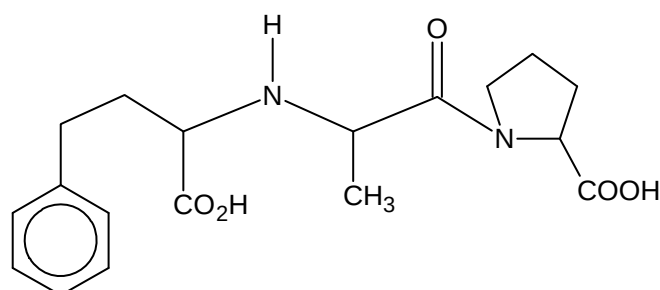


Formula: $C_{24}H_{32}N_2O_9$

Relative molecular mass: 492

Route of administration: Oral

Dosage forms: 2.5 mg, 5.0 mg, 10.0 mg and 20.0 mg tablets



Enalaprilate

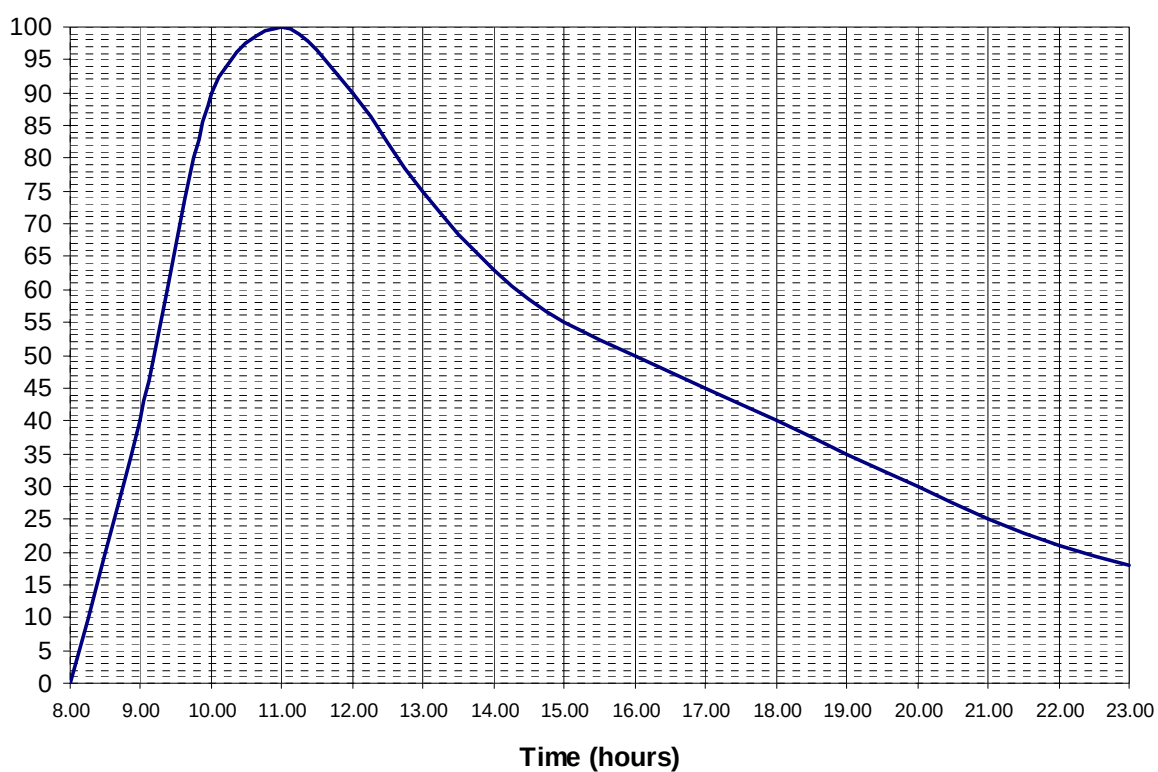
Formula: $C_{18}H_{24}N_2O_5$

Relative molecular mass: 348

- (a) In a trial, a 55-kg patient took a 5.0 mg tablet of *Enalapril maleate* at 8 am in the morning. The body requires about 3 hours for *Enalapril maleate* to be hydrolysed to *Enalaprilate*.

Samples of the patient's blood were taken at fixed time intervals to measure the concentration of *Enalaprilate* in the plasma. The results are shown in the graph on the following page.

% plasma concentration of *Enalaprilate*



Deduce the order of reaction with respect to *Enalaprilate*. Hence, construct the rate equation for the breakdown of *Enalaprilate* in the body.

[2]

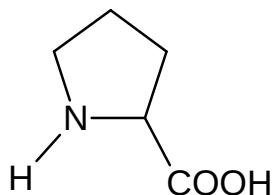
- (b) The toxicity level of *Enalapril maleate* is estimated to be approximately 71 μg per kg for human patients. Concentrations above this level would lead to harmful side effects.

Calculate the maximum number of 5.0 mg tablets that can be consumed by a 55-kg patient without any side effects, assuming that the body absorbs 60% of the administered dose and each tablet contains 50% by mass of *Enalapril maleate*.

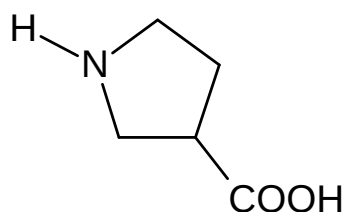
[1 μg = 1×10^{-6} g]

[2]

- (c) Prolonged hydrolysis of *Enalapril maleate* in the laboratory produces compound **A**. State, with reasoning, how you would expect the volatility of **A** to compare with its isomer, compound **B**.



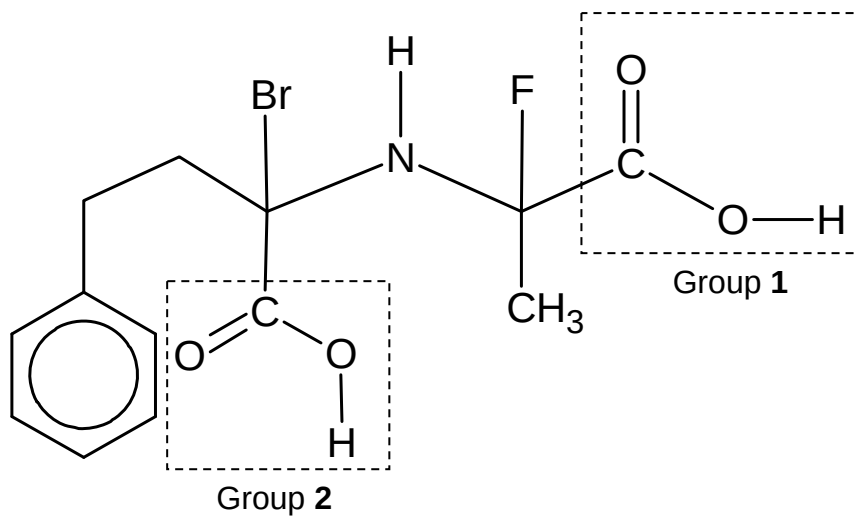
Compound **A**



Compound **B**

[3]

(d) Compound **C** is derived from *Enalaprilate*.



Compound **C**

C possesses two carboxylic acid functional groups **1** and **2**. When **C** reacts with a base, predict which group would donate its proton first.

Explain your answer.

[3]

[Total: 10]

END OF PAPER