IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

N05/4/CHEMI/HP3/ENG/TZ0/XX+

88056103

CHEMISTRY
HIGHER LEVEL
PAPER 3

Tuesday 8 November 2005 (morning)

1 hour 15 minutes

Candidate session number

0	0							

INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options in the spaces provided. You may continue your answers on answer sheets. Write your session number on each answer sheet, and attach them to this examination paper and your cover sheet using the tag provided.
- At the end of the examination, indicate the letters of the Options answered in the candidate box on your cover sheet and indicate the number of answer sheets used in the appropriate box on your cover sheet.

Option B – Medicines and drugs

B1. Magnesium hydroxide and aluminium hydroxide can act as antacids.

(a) Write an equation for the reaction of hydrochloric acid with one of the above antacids. *[2]*

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(b) Identify which antacid neutralizes the greater amount of hydrochloric acid if 0.1 mol of each antacid is used to neutralize the hydrochloric acid present in the stomach. *[1]*

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(c) Give **one** reason why sodium hydroxide is not used instead of these antacids. *[1]*

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B2. Acidified potassium dichromate(VI) is commonly used in roadside tests for ethanol in the breath of persons operating motor vehicles. It reacts with the ethanol present to form ethanoic acid.

(a) State the function of potassium dichromate(VI) and give the colour change that takes place in this reaction. *[2]*

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(b) Identify **two** other methods for the detection of ethanol in a persons breath or blood that are considered to be more accurate. *[2]*

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(c) State **one** harmful effect of aspirin that is more likely to occur if it is taken with ethanol. *[1]*

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B3. (a) Aspirin and acetaminophen (paracetamol) are classified as mild analgesics.

(i) State **one** advantage of aspirin, other than reducing pain, which is common to acetaminophen (paracetamol). *[1]*

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(ii) State **one** advantage of aspirin which is **not** common to acetaminophen (paracetamol). *[1]*

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(b) Morphine, codeine and heroin are classified as strong analgesics.

(i) Name **two** functional groups common to morphine, codeine and heroin. *[2]*

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(ii) A hospital patient has been prescribed morphine after surgery. State the main effect and a major side effect of this drug. *[2]*

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B4. (a) (i) State the names of **two** anti-cancer drugs which have different types of stereoisomerism. Identify the type of stereoisomerism present in each drug. *[2]*

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(ii) Describe the structural feature of each drug responsible for the type of stereoisomerism. *[2]*

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(b) Discuss the function of a chiral auxiliary in the preparation of one of the drugs. *[2]*

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B5. (a) Compare the modes of action of local and general anesthetics. *[2]*

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(b) Name **two** derivatives of cocaine that have a similar anesthetic mode of action. State **one** disadvantage of cocaine not possessed by these derivatives. *[2]*

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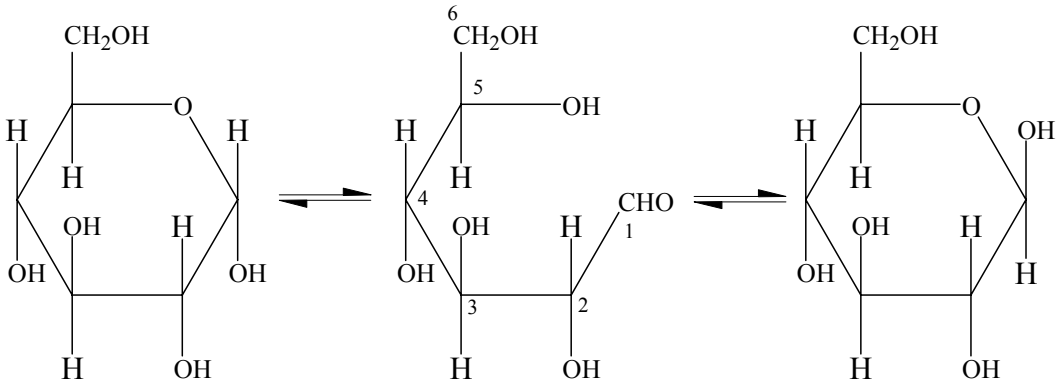
Option C – Human biochemistry

C1. (a) The equilibria which exists in an aqueous solution of glucose is shown in the structures below.



A B C

(i) Identify the α and β forms of glucose *[1]*

α glucose . . . . . .

β glucose . . . . . .

(ii) State, with a reason, whether or not the two ring forms of glucose are enantiomers. *[1]*

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(iii) In structure B identify, by stating the numbers, the carbon atoms which are **not** chiral. *[1]*

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(b) The structure of lactose, a disaccharide formed from glucose and galactose, is shown in the Data Booklet. Draw the ring structure of galactose and state whether it is an α or β isomer. *[2]*

C2. (a) The general formula for saturated fatty acids is $C_nH_{2n}O_2$. The molecular formula of linoleic acid is $C_{18}H_{32}O_2$.

(i) Determine the number of carbon to carbon double bonds in linoleic acid. *[1]*

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(ii) Iodine number is defined as the number of grams of iodine that adds to 100 g of a fat or an oil in an addition reaction. Determine the iodine number of linoleic acid. *[2]*

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(b) (i) State **one** structural similarity between fats and oils. *[1]*

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(ii) Explain, by referring to their structures, why fats are solid at room temperature, but oils are liquid. *[3]*

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C3. (a) State the name of a disease which results from the deficiency of each of the following vitamins. *[2]*

vitamin A . . . . . .

vitamin C . . . . . .

vitamin D . . . . . .

(b) A person consumes an excess of both vitamin A and C. State, with a reason, which **one** is more likely to be stored in the body and which is more likely to be excreted. *[2]*

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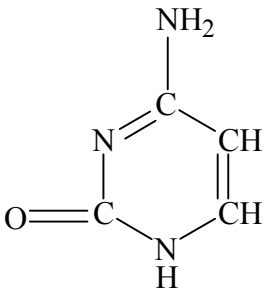
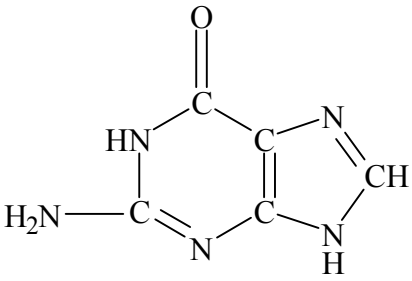
C4. (a) The structural formulas of cytosine and guanine present in nucleic acids are given below. Draw the correct number of hydrogen bonds between these two bases. *[2]*

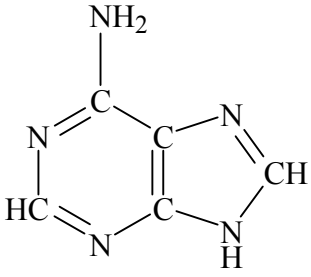


cytosine



guanine

(b) The structural formula of adenine is shown below. Copy an appropriate base from the Data Booklet present in RNA that will pair with adenine. Draw the correct number of hydrogen bonds between these two bases. *[2]*



adenine

(This question continues on the following page)

(Question C4 continued)

(c) Explain the term triplet code. *[1]*

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(d) State and explain which ions, sodium or potassium, pass more easily through the cell membrane. *[1]*

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(e) Food is oxidized by a series of redox reactions involving the transport of electrons. Identify the **ions** of two different metals, used in these reactions. *[2]*

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(f) The structure of the haem group from cytochrome oxidase is shown in Table 22 of the Data Booklet. Identify the type of bonding between iron and the four nitrogen atoms. *[1]*

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Option D – Environmental chemistry

D1. (a) (i) Identify **three** primary pollutants produced by the automobile engine and describe how each one is produced. *[4]*

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(ii) Write an equation for the reaction that takes place between two primary pollutants in a catalytic converter. *[1]*

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(b) Chlorofluorocarbons (CFCs) are one pollutant responsible for the depletion of the ozone layer. State **three** characteristic properties required for hydrofluorocarbons (HFCs) to be considered as alternative to CFCs. *[3]*

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D2. (a) List **three** different methods by which sea water can be converted into fresh water. Discuss the essential features of one of the methods. *[5]*

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(b) State **one** similarity and **one** difference between drinking water treatment with chlorine and ozone. *[2]*

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D3. (a) (i) Identify **two** primary pollutants in *reducing smog*. *[2]*

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(ii) Explain, with the help of equations and conditions, how a secondary pollutant is produced by two different mechanisms. *[4]*

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(iii) Outline a method by which the concentration of one of the primary pollutants can be reduced. *[1]*

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(b) Discuss the role of NO_x in the process of ozone depletion. Include equations for a stepwise mechanism in your answer. *[3]*

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Option E – Chemical industries

E1. Aluminium is extracted by the electrolysis of pure alumina in molten cryolite using graphite electrodes.

(a) Explain why aluminium is extracted by electrolytic reduction rather than carbon reduction. *[1]*

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(b) Explain why alumina has such a high melting point. *[1]*

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(c) Explain why molten cryolite is used in the extraction of aluminium. *[1]*

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(d) Write an ionic equation for the reaction that takes place at each electrode. *[2]*

positive electrode (anode) . . . . . .

negative electrode (cathode) . . . . . .

E2. (a) Apart from providing heat, state **one** other function of using coke in the blast furnace for the production of iron. *[1]*

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(b) Limestone is also added to the blast furnace. It decomposes to form calcium oxide and carbon dioxide. Identify the impurity removed by calcium oxide and explain why it reacts with this impurity. *[2]*

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(c) The basic oxygen converter is used to convert iron into steel. Molten impure iron from the blast furnace, scrap iron and two other substances are added to the converter.

(i) Name the **two** other substances added. *[2]*

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(ii) Explain the function of these **two** substances. *[2]*

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E3. (a) Hexane can be converted to different products by three types of reforming processes. State the name and formula of the organic product formed in each case. *[3]*

aromatization . . . . . .

cyclization . . . . . .

isomerization . . . . . .

(b) Outline **one** reason why sulfur compounds present in crude oil are removed. *[1]*

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E4. Most cracking processes used in the oil industry use either steam or a catalyst.

(a) Distinguish between these processes in terms of temperature, type of bond fission and name of the mechanism. *[3]*

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(b) State the name of the catalyst and the type of intermediate formed in catalytic cracking. *[2]*

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E5. Chlorine is produced on a large scale by electrolysis of brine (concentrated sodium chloride solution) using a diaphragm cell.

(a) Explain why brine is used in preference to molten sodium chloride for the large-scale production of chlorine. *[2]*

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(b) Write a half-equation for the reaction taking place at each electrode in the diaphragm cell *[2]*

positive electrode (anode)

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negative electrode (cathode)

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Option F – Fuels and energy

F1. The enthalpy of combustion values for three fossil fuels are as follows. (For coal and natural gas the major components are carbon and methane respectively. For petroleum, octane is one of the many components present).

		$\Delta H_c^\ominus$ / kJ mol^{-1}
coal	$C + O_2 \rightarrow CO_2$	–394
natural gas	$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$	–890
petroleum	$C_8H_{18} + 12\frac{1}{2}O_2 \rightarrow 8CO_2 + 9H_2O$	–5512

(a) If 1.00 g of coal on complete combustion produces 32.8 kJ of energy, determine the amount of energy produced when 1.00 g of each of the other two fossil fuels undergoes complete combustion. *[2]*

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(b) Compare the combustion of these fossil fuels as a source of air pollution by explaining the following.

(i) Coal produces the most sulfur dioxide. *[1]*

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(ii) Petrol (Gasoline) produces the most oxides of nitrogen. *[1]*

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(iii) All three fossil fuels produce carbon monoxide. *[1]*

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(This question continues on the following page)

(Question F1 continued)

(c) Write an equation for the formation of carbon monoxide by the combustion of natural gas. *[1]*

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(d) Calculate the volume of air needed for the complete combustion of 100 dm^3 of pure methane. (Assume that air contains 20 % oxygen by volume.) *[2]*

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(e) Octane rating is a measure of the ability of a fuel to resist "knocking" when burned in a standard test engine. Draw the structural formula of the compound with octane number 0 and the compound with octane number 100. *[2]*

octane number 0 . . . . . .

octane number 100 . . . . . .

F2. The following reaction takes place in a lead-acid storage battery.

$$2PbSO_4(s) + 2H_2O(l) \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftharpoons}} Pb(s) + PbO_2(s) + 2H_2SO_4(aq)$$

(a) State the half-equations taking place at the negative electrode (anode) and the positive electrode (cathode) during the discharge of this battery. *[2]*

negative electrode (anode) . . . . . .

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positive electrode (cathode) . . . . . .

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(b) State **one** change in the electrolyte during the discharge process. *[1]*

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(c) State **one** advantage and **one** disadvantage of a lead-acid storage battery compared to a zinc-carbon battery. *[2]*

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F3. (a) Explain why carbon (in the form of diamond) does not conduct electricity but germanium is a semi conductor. *[2]*

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(b) Discuss the **two** types of doping of silicon when small amounts of indium and arsenic are added. Name the type of semi-conductors produced in each case. *[4]*

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F4. State **two** advantages and **two** disadvantages of using hydrogen as an energy source. *[4]*

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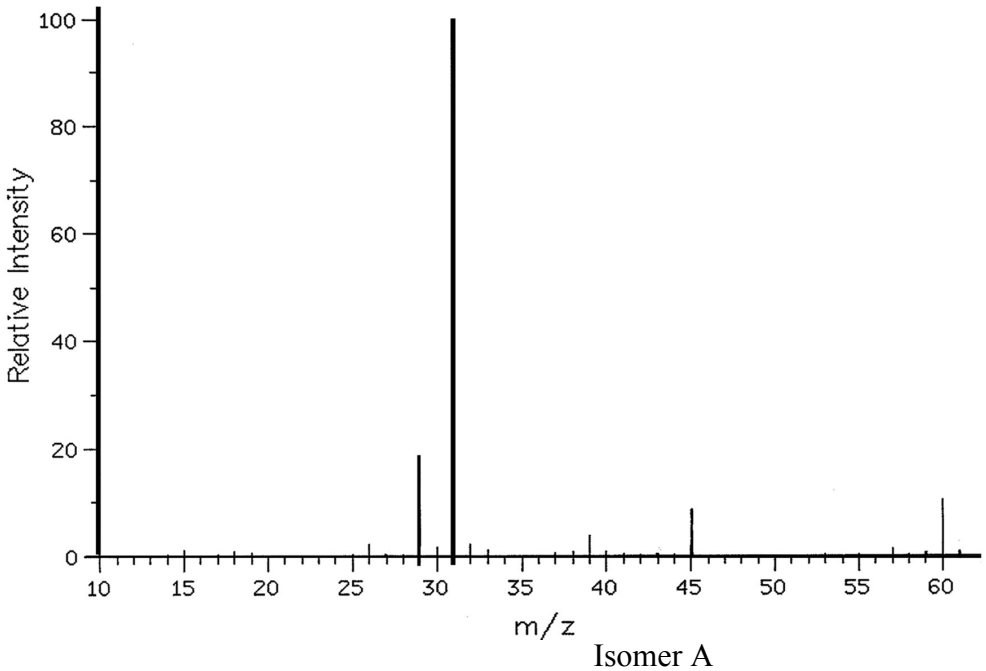
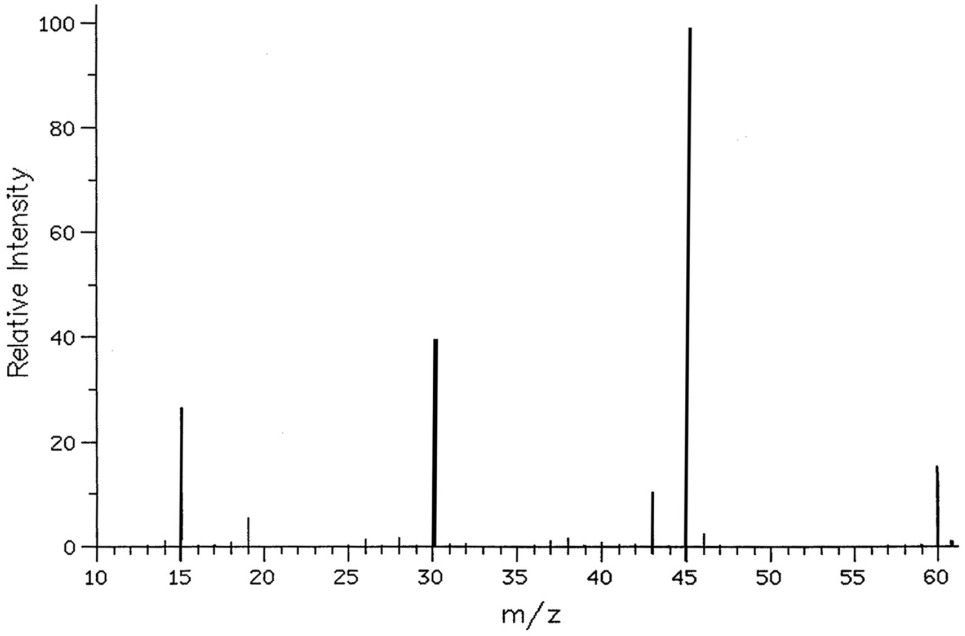
Option G – Modern analytical chemistry

G1. An organic compound with three carbon atoms has two structural isomers **A** and **B** with the same functional group. The infrared spectrum of the compound shows a broad absorption at about $3350\,cm^{-1}$.

(a) The mass spectra of the two isomers **A** and **B** are as follows.



Isomer A



Isomer B

(This question continues on the following page)

(Question G1 continued)

(i) Deduce, giving a reason, the molecular formula of the organic compound. *[1]*

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(ii) Deduce the formula of the fragmentation ion responsible for the peak at each of these m/z values. *[4]*

isomer A 29 . . . . . .

31 . . . . . .

isomer B 30 . . . . . .

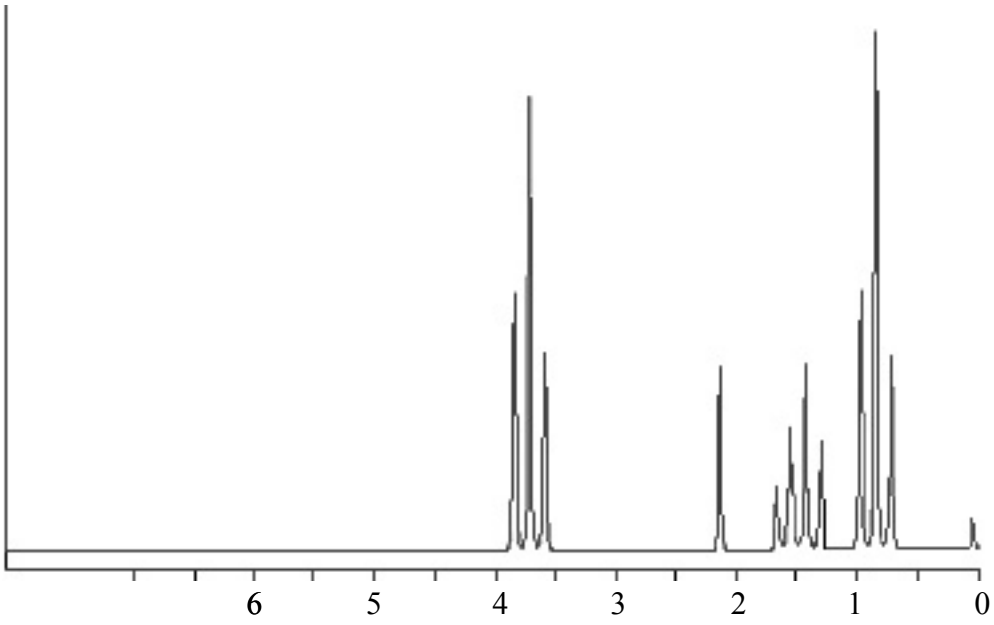
45 . . . . . .

(This question continues on the following page)

(Question G1 continued)

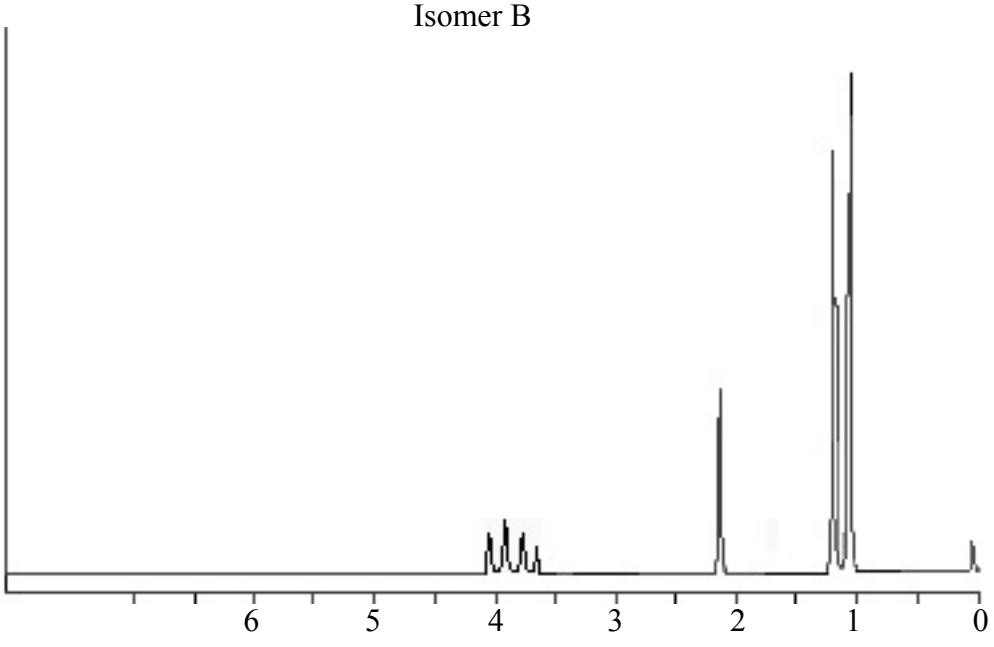
(b) The ^{1}H NMR spectra of isomers **A** and **B** are shown below.

Isomer A



chemical shift δ / ppm

Isomer B



chemical shift δ / ppm

(This question continues on the following page)

(Question G1 continued)

(i) State the formula and function of the compound responsible for the peak at 0 ppm. *[2]*

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(ii) Explain what information about the isomers can be obtained from the number of peaks and area under each peak. *[2]*

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(iii) Deduce the structural formulas of isomers **A** and **B** and give the ratio of peak areas in each case. *[4]*

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(iv) Draw the structural formula of a third isomer **C** that has the same molecular formula as isomers **A** and **B** but a different functional group. Give the ratio of peak areas in isomer **C**. *[2]*

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G2. (a) Describe a chromatographic technique used to identify the amino acids formed when a protein is hydrolysed. *[4]*

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(b) Suggest a chromatographic technique that could be used to detect the alcohol concentration in a sample of blood. Outline the essential features of this technique. *[6]*

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Option H – Further organic chemistry

H1. (a) Compounds of formula C_4H_7Cl exhibits both geometrical and optical isomerism.

(i) Explain why C_4H_7Cl shows geometrical isomerism. *[1]*

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(ii) Draw the cis and trans isomers of C_4H_7Cl. *[2]*

(iii) Draw the structural formula of C_4H_7Cl that shows only optical isomerism. Show the chiral carbon atom with " * ". *[2]*

(b) Explain why 1,2-dichlorocyclopropane has *cis* and *trans* isomers. Draw the structural formulas of the two isomers. *[3]*

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H2. On being reacted separately with HBr, 2-methylbut-1-ene and 2-methylbut-2-ene produce the same major product but different minor products.

(a) Draw the structural formula of the major product and explain why it is formed in terms of the stability and structure of the organic intermediate. *[4]*

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(b) Draw the structural formulas of the two minor products. *[2]*

H3. (a) Name and outline the mechanism for the reaction of ethanal with hydrogen cyanide. *[5]*

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(b) Give the structure of the compound formed when the product from reaction (a) is hydrolysed. *[1]*

(c) Explain why a sample of the compound formed in (b) does not show optical activity. *[1]*

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H4. (a) Explain why aminoethane (ethylamine) is more basic than ammonia. *[2]*

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(b) Explain why 2, 4, 6-trinitrophenol is more acidic than phenol. *[2]*

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