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

M07/4/CHEMI/HP3/ENG/TZ0/XX

22076103

CHEMISTRY
HIGHER LEVEL
PAPER 3

Friday 11 May 2007 (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.

0131

Option B – Medicines and drugs

B1. Ethanol in the human body can be detected in several ways.

(a) Explain how the breathalyser works and describe its colour change in a positive result. *[2]*

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(b) Explain how alcohol is detected using an intoximeter. *[2]*

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B2. The structures of some stimulants can be found in Table 21 of the Data Booklet.

(a) Compare the structures of caffiene and nicotine in terms of functional groups. *[2]*

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(b) Discuss **two** short-term effects of smoking tobacco. *[2]*

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B3. (a) Describe the differences in the ways that bacteria and viruses multiply. *[2]*

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(b) Outline **two** ways in which antiviral drugs work. *[2]*

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(c) Explain why effective treatment of AIDS with antiviral drugs is difficult. *[2]*

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B4. The structures of adrenaline and cisplatin are shown in Table 21 of the Data Booklet. Both compounds exist as stereoisomers.

(a) Describe the structural feature of the adrenaline molecule responsible for this type of isomerism. *[1]*

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(b) Draw diagrams to show the structures of these two stereoisomers, showing clearly the relationship between them. Use the symbol **X** to represent the benzene ring with its attached OH groups. *[2]*

(c) (i) Identify the **two** types of bonding in the cisplatin molecule and predict the name of its shape and the Cl–Pt–Cl bond angle. *[3]*

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(ii) Draw the structure of the stereoisomer of cisplatin. *[1]*

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

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(b) An anesthetic mixture contains 0.150 mol of cyclopropane and 1.10 mol of oxygen at a total pressure of 105 kPa.
Calculate the partial pressure (in kPa) of cyclopropane in this mixture. *[2]*

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Option C – Human biochemistry

C1. (a) The structures of the amino acids glycine and serine are shown in Table 20 of the Data Booklet. Draw the structure of one of the dipeptides formed when one molecule of glycine and one molecule of serine react together. Show all the bonds in the link between the two molecules. *[2]*

(b) The structure of a protein can be analysed using paper chromatography.

(i) Describe the process that the protein must undergo before chromatography is used and explain why it is necessary. *[2]*

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(ii) Explain how paper chromatography is used to identify the individual amino acids. *[4]*

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C2. Fats and oils are formed when fatty acids react with glycerol.

(a) Outline **two** structural differences between saturated and unsaturated fats. *[2]*

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(b) Explain why saturated fats have higher melting points than unsaturated fats with similar relative molecular masses. *[2]*

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C3. The structures of some hormones are shown in Table 22 of the Data Booklet.

(a) Identify **one** hormone with a steroid backbone, state where it is produced and outline its specific role in the body. *[2]*

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(b) Identify **one** hormone with a non–steroid backbone, state where it is produced and outline its specific role in the body. *[2]*

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C4. (a) Explain, with reference to the active site, how enzymes are able to catalyse biological reactions. *[3]*

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(b) State and explain the effect on the rate of an enzyme-catalysed reaction of gradually increasing the temperature from 10 °C to 60 °C. *[4]*

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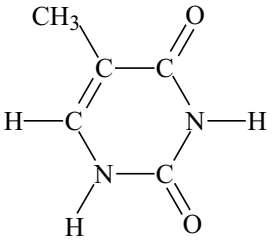
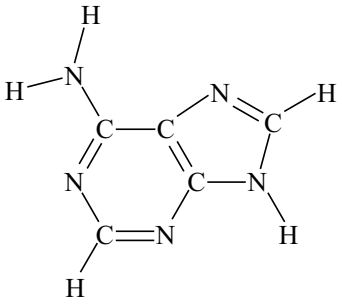
C5. The structures of four organic bases present in DNA are shown below.

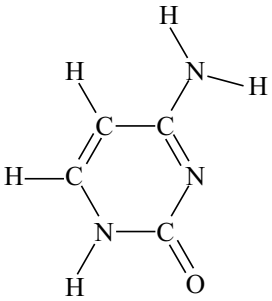
Use dotted lines to represent the hydrogen bonds that form between thymine and adenine, and between cytosine and guanine. *[2]*



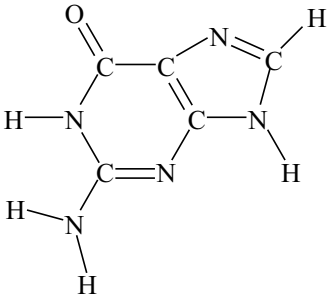
thymine



adenine



cytosine



guanine

Option D – Environmental chemistry

D1. The natural greenhouse effect can be summarised in these steps.

I. About half of the radiation entering the Earth's atmosphere is absorbed by the Earth's surface.
II. This absorbed radiation is re-radiated from the Earth's surface.
III. Greenhouse gases in the atmosphere absorb the radiation from the Earth's surface and re-radiate it back to the Earth's surface.

(a) (i) Identify the part of the spectrum from which most of the absorbed radiation in step I comes. *[1]*

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(ii) Identify the part of the spectrum from which most of the radiation in step II comes. *[1]*

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(iii) Explain on a molecular level, how greenhouse gases absorb the radiation in step III. *[1]*

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(iv) The term *enhanced greenhouse effect* is sometimes used to describe the increasing effect of human activity on the natural effect.
Explain why, with reference to one of the steps above, the greenhouse effect may be increasing. *[2]*

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(b) "Carbon dioxide is the most significant greenhouse gas."
"Methane is a more important greenhouse gas than carbon dioxide."
Explain how both these statements can be considered correct. *[2]*

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D2. (a) The pH values of five liquids are 1.2, 4.2, 5.2, 6.2 and 7.2. Identify which **two** of these values are most likely to be those of acid rain. *[1]*

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(b) Identify an oxide that causes acid rain and write an equation for its reaction with water. *[2]*

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(c) State **two** ways in which emissions of the oxide identified in (b) can be decreased. *[2]*

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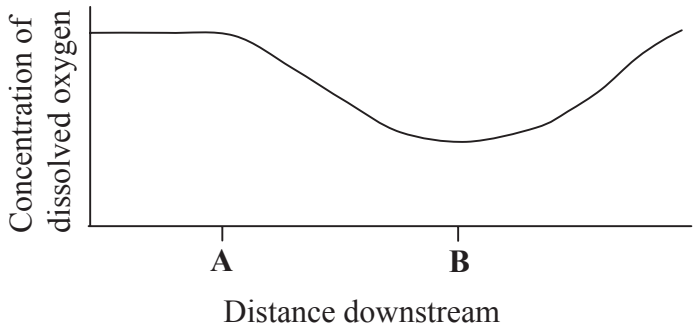
D3. The diagram below represents the variation in dissolved oxygen along a river.



(a) Explain the meaning of the term *biological oxygen demand* (BOD). *[2]*

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(b) (i) Identify, giving a reason, at which of the points **A** or **B** the BOD is greater. *[1]*

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(ii) Suggest a reason for the change in the amount of dissolved oxygen between **A** and **B**. *[1]*

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D4. This question concerns some of the reactions that lead to air pollution.

(a) Name the molecule formed in the following reaction, classify it as a primary or secondary pollutant, and describe a process that would cause this reaction to occur. *[2]*

$$N_2 + O_2 \rightarrow 2NO$$

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(b) Name the molecule formed in the following reaction and classify it as a primary or secondary pollutant. For the other product explain what the symbol • represents and state the name of this type of species. *[3]*

$$CH_3CH_2O\bullet + O_2 \rightarrow CH_3CHO + HO_2\bullet$$

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D5. Trichlorofluoromethane, CCl_3F, is one CFC responsible for ozone depletion in the atmosphere. It is involved in a three-step mechanism, described as follows.

I. The compound breaks down in ultraviolet light to form radicals
II. Ozone is converted into ClO•
III. Oxygen atoms are involved in the formation of Cl•

Write equations to show each step in this mechanism and explain why one CFC molecule is able to destroy many ozone molecules. *[4]*

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Option E – Chemical industries

E1. Identify **two** raw materials mixed with the iron ore in a blast furnace. In each case, outline its purpose and write an equation to show what happens to it in the blast furnace. *[5]*

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E2. (a) Approximately 90 % of the refined products from crude oil are used for one main purpose. Identify this purpose and explain why the other 10 % are of great importance. *[2]*

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(b) Deduce the equation for the cracking of C_8H_{18} in which an alkene and an alkane are formed in the ratio 2 : 1. *[1]*

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(c) Explain why sulfur and its compounds are removed from crude oil, and identify one industry that makes use of this sulfur. *[2]*

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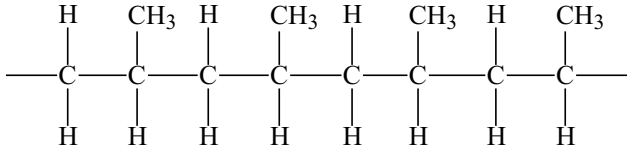
E3. The diagram below represents a section of a polymer.



(a) (i) Polymers **A** and **B** both have the structure shown above, but the average chain length is much greater in **A** than in **B**. Suggest **two** physical properties that would be different for **A** and **B**. *[2]*

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(ii) Polymers **A** and **B** both have isotactic structures. Polymer **C** is manufactured from the same monomer but is not isotactic. State the name used to describe this different structure and outline how the structure differs. *[2]*

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(b) Polymers have replaced more traditional materials such as metal and wood. Suggest **one** polymer property, different in each case, that makes polymers more suitable than *[2]*

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wood . . . . . .

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E4. Use information from Table 12 in the Data Booklet to answer this question.

(a) Deduce the temperature above which zinc oxide can be decomposed into its elements by heat alone. Give a reason for your answer. *[2]*

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(b) Deduce the minimum temperature needed for zinc oxide to be converted into zinc in the presence of carbon. *[1]*

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E5. (a) Describe the chlor-alkali process, include the reactants, conditions and the products formed. Write an equation for the reaction at the positive electrode (anode). *[3]*

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(b) In the chlor–alkali industry the mercury cell has been replaced by cells that are less polluting.

(i) State **one** harmful effect of releasing mercury into the environment. *[1]*

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(ii) Describe **one** of the ways in which these less polluting cells are able to keep the reaction products separate from each other. Write an equation for the reaction that occurs at the negative electrode (cathode) in these cells. *[2]*

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Option F – Fuels and energy

F1. (a) Methane undergoes complete combustion as shown below.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) \quad \Delta H = -802 \text{ kJ mol}^{-1}$$

(i) Determine the calorific value of methane in kJ g^{-1}. *[1]*

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(ii) The amount of heat produced when a 20.0 g sample of one type of coal was completely burned was 610 kJ. Determine the calorific value in kJ g^{-1}. *[1]*

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(iii) The data above show that the calorific value of methane is higher than that of coal. State **two** other reasons why methane is often described as a better fuel than coal. *[2]*

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(iv) Explain why coal will continue to be used as a fuel in the future. *[1]*

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(b) State an equation for the gasification of coal, in which a mixture of two flammable gases is formed. *[1]*

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F2. Nuclear reactions can be classified as disintegration, fission or fusion reactions.
A typical disintegration reaction involves the loss of an alpha or beta particle from a radioactive isotope.
A typical fission reaction involves the bombardment of an unstable nucleus by neutrons, forming two smaller nuclei and releasing more neutrons.
A typical fusion reaction involves two small nuclei combining to form a larger nucleus.

(a) Deduce a balanced nuclear equation, showing the atomic number and mass number of each species, for the following examples.

(i) The disintegration of radium-226 to form radon-222. *[1]*

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(ii) The fission of uranium-235 to form lanthanum-145 and bromine-88. *[1]*

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(iii) The fusion of a nucleus of ordinary hydrogen with ^{2}H to form a helium nucleus. *[1]*

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(b) Compare the behaviour of alpha and beta particles in an electric field. *[2]*

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F3. Compare the ways in which houses can be heated using solar energy. Include in your answer reference to

- the distinction between active and passive solar heating
- the direct and indirect conversion of solar energy to electricity. *[4]*

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F4. (a) Describe what is meant by the term *mass defect*, using helium as an example. *[2]*

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(b) Use information from Tables 1 and 2 in the Data Booklet, and the following relative masses, to answer this part.

relative mass of proton = 1.007270
relative mass of neutron = 1.008665
relative mass of electron = 0.000549

Calculate the change in mass (in kg mol^{-1}) that occurs in the following reaction, and hence the energy released: *[3]*

$$^{209}Pb \rightarrow {}^{209}Bi + {}^{0}_{-1}e$$

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F5. Discuss the use of silicon in photovoltaic cells, with reference to the following:

- why pure silicon is a better electrical conductor than non-metals such as phosphorus and sulfur
- how a p-type semiconductor made from silicon is different from pure silicon
- how sunlight can produce an electric current in a photovoltaic cell. *[5]*

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Option G – Modern analytical chemistry

G1. (a) Describe what happens to the fundamental particles in an atom when it absorbs visible light. *[1]*

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(b) (i) Explain, with reference to the d orbitals in a transition metal, why complex ions are coloured. *[3]*

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(ii) Outline why different ligands produce different colours with the same transition metal. *[2]*

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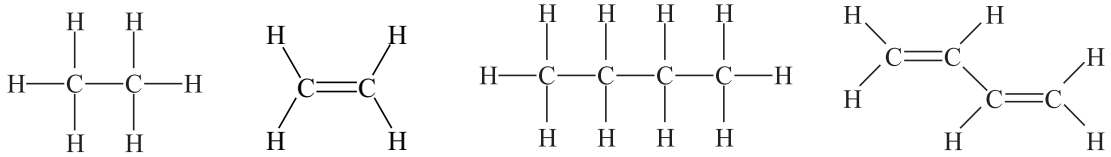
(c) The structures of four hydrocarbons are shown below.



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(i) Identify the compounds that most strongly absorb ultraviolet radiation. *[1]*

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(ii) Identify the compound that absorbs ultraviolet radiation of the longest wavelength, and explain your choice. *[2]*

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G2. (a) Describe what occurs at a molecular level when molecules such as carbon dioxide absorb infrared radiation. *[2]*

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(b) Spectra **A** and **B** on page 25, represent the infrared spectra of two of these compounds:

CH_3CH_2COOH CH_3COOCH_3 $HCOOCH_2CH_3$

(i) Use Table 18 in the Data Booklet to identify the groups responsible for the absorption near *[1]*

$1050\ cm^{-1}$ . . . . . .

$1700\ cm^{-1}$ . . . . . .

(ii) Deduce which **one** of the three compounds produced spectrum **A**, giving a reason for your choice. *[2]*

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(iii) Explain why the other two compounds have similar infrared spectra. *[1]*

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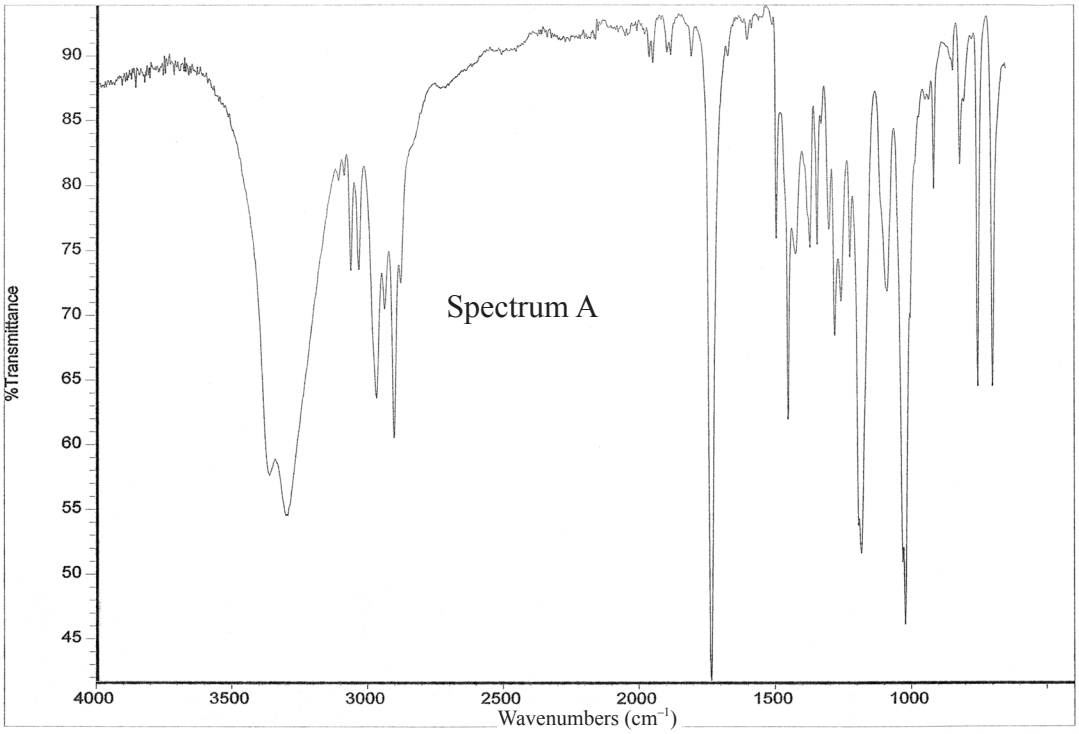
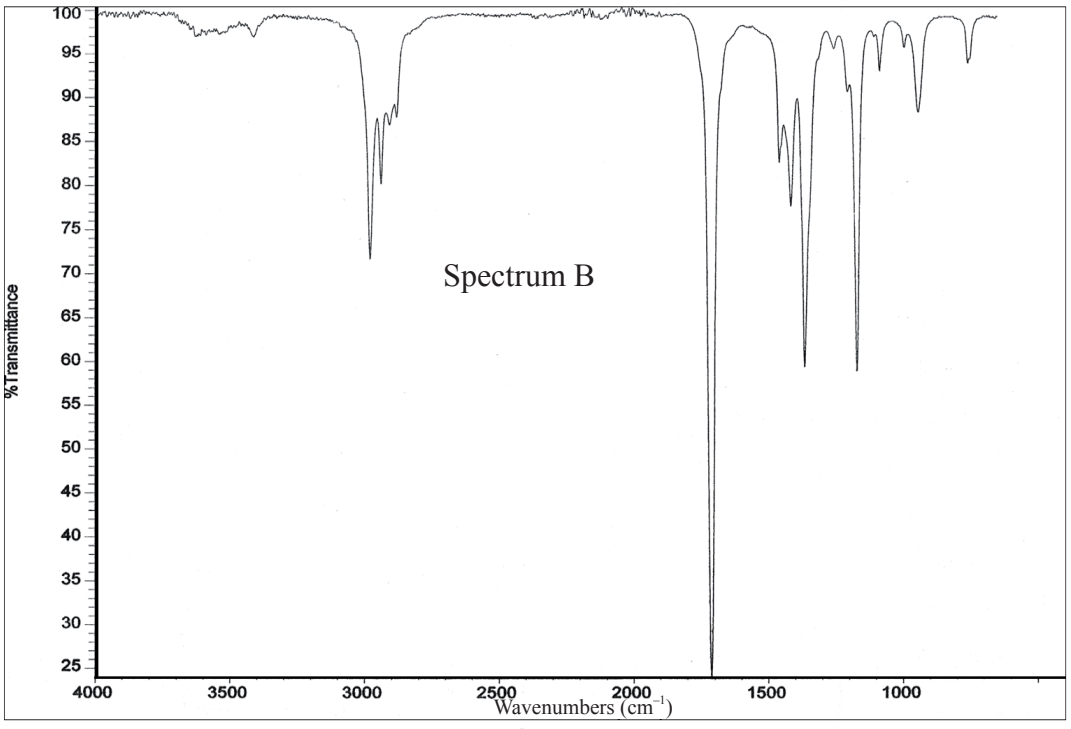
(This question continues on the following page)

(Question G2 continued)





(This question continues on the following page)

(Question G2 continued)

(c) Figures **C** and **D** represent the splitting patterns and the chemical shifts shown in the ^{1}H NMR spectra of the same two compounds used to obtain spectra **A** and **B**.

Figure C

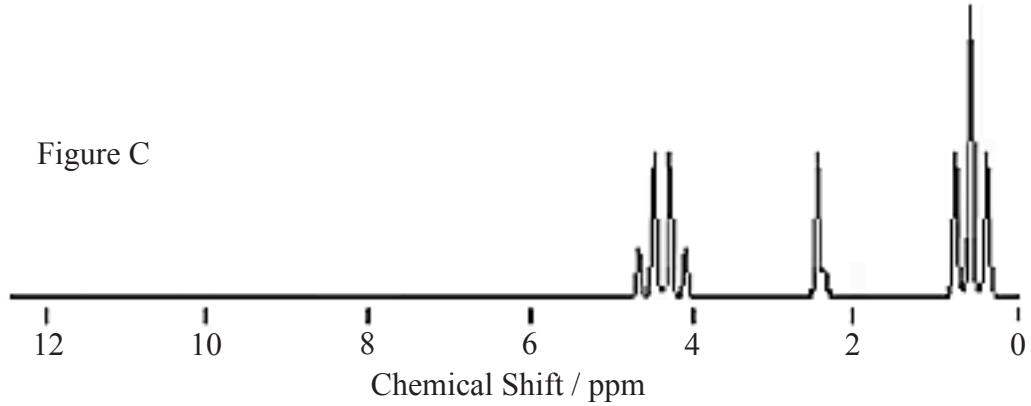
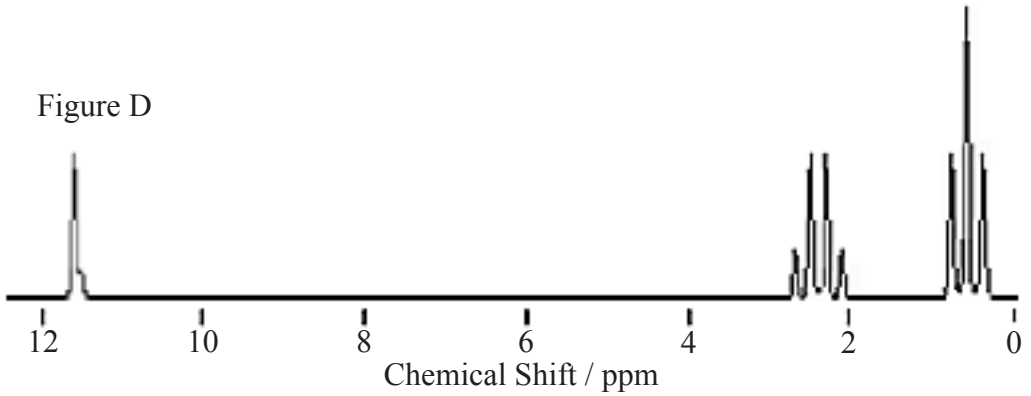


Figure D



(i) State what general information can be deduced from the three different types of splitting patterns in these spectra. *[3]*

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(ii) Explain how the chemical shift values close to δ 4.1 in figure **C** and close to δ 11.5 in figure **D** can be used to identify the two compounds. Refer to information from Table 19 in the Data Booklet in answering this part. *[2]*

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G3. Paper chromatography and column chromatography can be used as examples to explain the difference between adsorption and partition. For each of these chromatographic techniques, identify

- the stationary and mobile phases
- how the mobile phase moves.

Identify, with a reason, which of the two techniques is more suitable for collecting samples of a mixture for further analysis. *[5]*

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Option H – Further organic chemistry

H1. Compounds with the molecular formula $C_3H_4Cl_2$ exist as several structural isomers, some of which are cyclic. Some of these structural isomers exist as geometric isomers.

(a) Explain why geometrical isomerism is possible in the non-cyclic isomers. *[1]*

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(b) Draw the structure of a non-cyclic structural isomer that does not exist as geometric isomers, and explain why geometrical isomerism is not possible in this compound. *[2]*

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(c) 1,3-Dichloropropene exists as geometric isomers. Draw and label the structures of its cis and trans isomers. *[2]*

(d) Draw structures to show the two geometric isomers of 1,2-dichlorocyclopropane. *[2]*

H2. (a) The equation for a reaction of ethane is

$$CH_3CH_3 + Cl_2 \rightarrow CH_3CH_2Cl + HCl$$

The mechanism of this reaction involves initiation, propagation and termination steps. Describe this reaction, including equations for each step and the role of ultraviolet light. *[5]*

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(b) Identify the organic product of the reaction between methylbenzene and chlorine in the presence of ultraviolet light. *[1]*

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H3. Methylbenzene and chlorine react together in a 1:1 ratio in the presence of iron(III) chloride.

(a) State the type of mechanism of this reaction and write an equation to show how iron(III) chloride generates the attacking species. *[2]*

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(b) Use equations to explain the mechanism of this reaction, representing the movement of electron pairs by curly arrows. *[4]*

H4. Table 16 in the Data Booklet contains pK_a values for organic compounds.

(a) Write an equation for the dissociation of 2-nitrophenol in aqueous solution. Explain, with reference to its structure and this equation, why 2-nitrophenol is a stronger acid than phenol. *[3]*

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(b) Write an equation to show how methylamine acts as a base in aqueous solution. Explain, with reference to its structure and this equation, why dimethylamine is a stronger base than methylamine. *[3]*

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