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

N02/420/H(3)

CHEMISTRY
HIGHER LEVEL
PAPER 3

Tuesday 19 November 2002 (morning)

1 hour 15 minutes

Name

Number

INSTRUCTIONS TO CANDIDATES

- Write your candidate name and 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 in a continuation answer booklet, and indicate the number of booklets used in the box below. Write your name and candidate number on the front cover of the continuation answer booklets, and attach them to this question paper using the tag provided.
- At the end of the examination, indicate the letters of the Options answered in the boxes below.

OPTIONS ANSWERED		EXAMINER	TEAM LEADER	IBCA
		/25	/25	/25
		/25	/25	/25
NUMBER OF CONTINUATION BOOKLETS USED	. . . . .	TOTAL /50	TOTAL /50	TOTAL /50

Option C – Human biochemistry

C1. Insulin and thyroxine are hormones produced in the human body.

(a) State which **two** parts of the body control their production. *[2]*

. . . . . .

. . . . . .

(b) For each hormone, state where it is produced and outline **one** function in the human body. *[4]*

insulin . . . . . .

. . . . . .

. . . . . .

thyroxine . . . . . .

. . . . . .

. . . . . .

C2. (a) Fats and oils can be hydrolyzed to fatty acids. Identify the other product of this hydrolysis. *[1]*

. . . . . .

(b) Fatty acids can be saturated or unsaturated. Three examples found in foods are $C_{15}H_{31}COOH$, $C_{17}H_{31}COOH$ and $C_{17}H_{35}COOH$.

(i) Explain the term *unsaturated*. *[1]*

. . . . . .

. . . . . .

(ii) List the three fatty acids in **decreasing** order (starting with the highest value) of melting point. *[1]*

. . . . . .

(iii) Identify the type of intermolecular force present in each of the fatty acids. *[1]*

. . . . . .

(iv) By reference to the structure of the following molecules, explain the difference in melting point in each pair. *[2]*

$C_{15}H_{31}COOH$ and $C_{17}H_{35}COOH$

. . . . . .

. . . . . .

$C_{15}H_{31}COOH$ and $C_{17}H_{31}COOH$

. . . . . .

. . . . . .

(c) 1.00×10^{-3} mol of peanut oil was found to react with 0.254 g of iodine. Calculate the amount of iodine (in mol) that reacted, and state what can be deduced about the structure of the oil. *[3]*

. . . . . .

. . . . . .

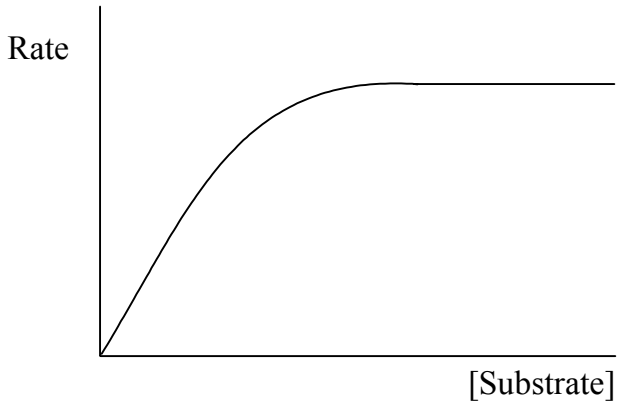
. . . . . .

. . . . . .

. . . . . .

. . . . . .

C3. A typical graph for the relationship between the rate of an enzyme-catalyzed reaction and substrate concentration is shown below.



Draw on the graph above the curves that would be obtained in the presence of a competitive inhibitor (labelled C) and a non-competitive inhibitor (labelled N). Explain the shapes of the curves. *[5]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

C4. Metal ions of d-block elements are important in biological processes, such as electron transport and oxygen transport. For **one** of these processes, give the name of the organic molecule and the metal ion it contains. By reference to its structure, explain how the molecule functions in the human body. *[5]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Blank page

Option D – Environmental chemistry

D1. The presence of small amounts of ozone in the upper atmosphere is necessary for human health.

(a) Write equations (two in each case) to show the natural formation and depletion of ozone in the upper atmosphere. *[4]*

ozone formation . . . . . .

. . . . . .

ozone depletion . . . . . .

. . . . . .

(b) CFCs are substances that have caused a decrease in atmospheric ozone concentration in recent years.

(i) State what the letters CFC stand for and list **two** sources of CFCs in the atmosphere. *[3]*

. . . . . .

. . . . . .

. . . . . .

(ii) Outline **two** harmful effects on human health due to the decrease in atmospheric ozone. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(iii) Discuss **two** disadvantages of using C_4H_{10} as an alternative to CFCs. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

D2. Many impurities in waste water are removed by secondary treatment. Describe how this is done. *[4]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

D3. The oxides of nitrogen in vehicle exhaust emissions can contribute to photochemical smog.

(a) Discuss the atmospheric and land features that favour the formation of photochemical smog in large cities. *[4]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Ozone is a secondary pollutant present in photochemical smog. It is formed by free radical mechanisms. State what is meant by the term *free radical*, and use equations to explain how ozone is formed from nitrogen(II) oxide, NO. *[4]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) State **one** type of secondary pollutant formed from hydrocarbons in photochemical smog and outline **one** harmful effect of the pollutant. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Blank page

Option E – Chemical industries

E1. The gases in air (mostly nitrogen, oxygen and argon) can be obtained by liquefaction and fractional distillation.

(a) Outline the processes used to liquefy air. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Use information from Table 6 of the Data Booklet to identify the gas given off first when liquid air is warmed. *[1]*

. . . . . .

(c) State **one** use each for nitrogen and oxygen obtained in this way. *[2]*

nitrogen . . . . . .

. . . . . .

oxygen . . . . . .

. . . . . .

E2. Two important processes in the oil industry are cracking and reforming. Each of these processes is carried out in various ways, depending on the product required.

(a) (i) Give an equation to show the thermal cracking of dodecane, $C_{12}H_{26}$, into two molecules, one of which contains eight carbon atoms. *[1]*

. . . . . .

. . . . . .

(ii) State the catalyst used in catalytic cracking. *[1]*

. . . . . .

(iii) One type of molecule found in the products of thermal and catalytic cracking is not formed in hydrocracking. Identify this type of molecule and explain why it is not formed. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Hexane, C_6H_{14}, can be reformed by aromatization. State the names of the **two** products of the reaction and write an equation for the reaction. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) Deduce the type of reforming taking place when hexane is converted into each of the following: *[2]*

$(CH_3CH_2)_2CHCH_3$ . . . . . .

$(CH_2)_6$ . . . . . .

E3. For most of the reactions shown in Table 12 of the Data Booklet, the standard Gibbs free energy change, $\Delta G^{\ominus}$, increases (becomes more positive) as the temperature increases.

(a) Explain why $\Delta G^{\ominus}$ increases for the reaction between iron and oxygen in the temperature range 500 to 1500 K. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) $\Delta G^{\ominus}$ for the reaction between carbon and oxygen to form carbon dioxide, CO_2, changes very little with temperature. $\Delta G^{\ominus}$ for the reaction between carbon and oxygen to form carbon monoxide, CO, becomes more negative as the temperature increases. Explain this difference. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

E4. Describe the steps by which silicon dioxide, SiO_2, is converted into pure silicon, suitable for use in semiconductors. *[4]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Blank page

Option F – Fuels and energy

F1. Two important fossil fuels are coal and oil.

(a) Describe how coal was formed. *[4]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Discuss the advantages and disadvantages of coal and oil as fuels by comparing their availability, method and cost of production, and environmental impact. *[5]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

F2. Ethanol is an example of a biofuel whose production depends indirectly on the sun.

(a) Name the process in which the sun's energy is used to form glucose, $C_6H_{12}O_6$, and write an equation for the process. *[3]*

. . . . . .

. . . . . .

. . . . . .

(b) Name the process in which glucose is converted to ethanol, and write an equation for the process. *[3]*

. . . . . .

. . . . . .

. . . . . .

F3. (a) Cobalt-60 is a radioactive isotope with a half-life of 5.27 years. Write a nuclear equation for its decay by β emission. Explain the term *half-life* and calculate the time for a sample of cobalt-60 to decay to 10 % of its original mass. *[4]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) The accurate value for the molar mass of lead-204 is $0.203973\ \text{kg mol}^{-1}$. The mass of 82 protons and 122 neutrons is 3.415015×10^{-25} kg. Explain the terms *mass defect* and *binding energy per nucleon* and calculate their values for lead-204. *[6]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Blank page

Option G – Modern analytical chemistry

G1. Two organic compounds, **A** and **B**, reacted in the presence of warm concentrated sulfuric acid to produce compound **C** and water. Analysis of compound **C** showed that it contained 48.6 % carbon, 8.20 % hydrogen and 43.2 % oxygen by mass.

(a) Determine the empirical formula of compound **C**. *[2]*

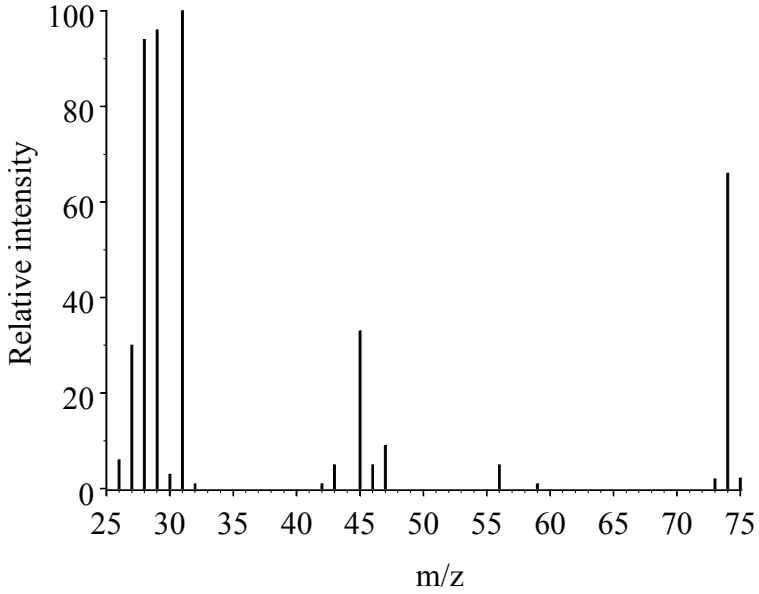
. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) The mass spectrum of compound **C** is given below.



[Source: SDBSWeb:/http//riodb.aist.go.jp/SDBS/]

(i) Deduce the molecular formula of compound **C**. *[1]*

. . . . . .

. . . . . .

(ii) Explain why there is a small peak at m/z = 75. *[1]*

. . . . . .

. . . . . .

(This question continues on the following page)

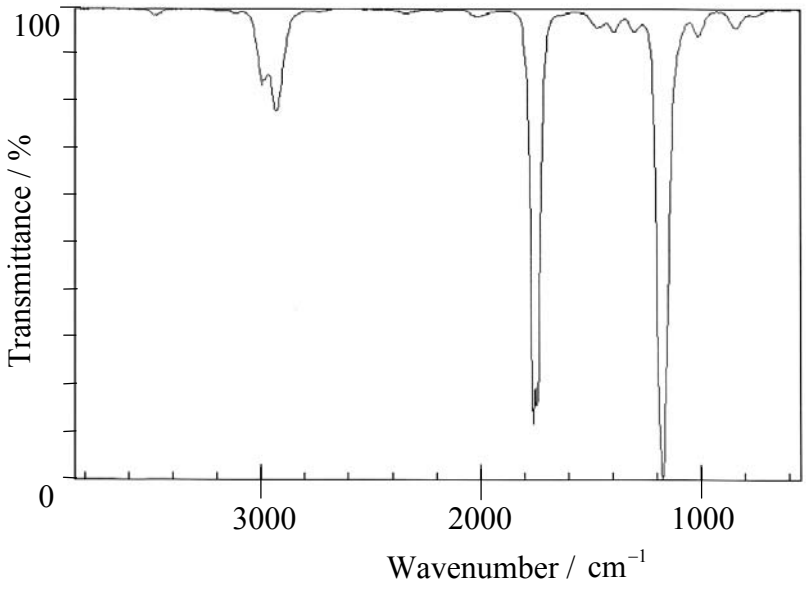
(Question G1 continued)

(iii) Suggest the formula of the fragmentation ions responsible for the peaks at each of these m/z values. *[2]*

29 . . . . . .

45 . . . . . .

(c) Compounds **A** and **B** both show a broad absorption close to $3250\ cm^{-1}$ in their infrared spectra. The infrared spectrum of compound **C** is shown below.



[Source: Chemistry Web Book (http://webbook.nist.gov/chemistry)]

(i) State what information about compound **C** can be deduced from the absence of an absorption close to $3250\ cm^{-1}$ in its infrared spectrum. *[1]*

. . . . . .

. . . . . .

(ii) There are absorptions at 2950, 1750 and $1180\ cm^{-1}$ in the spectrum above. Identify the bond responsible in each case. *[3]*

$2950\ cm^{-1}$ . . . . . .

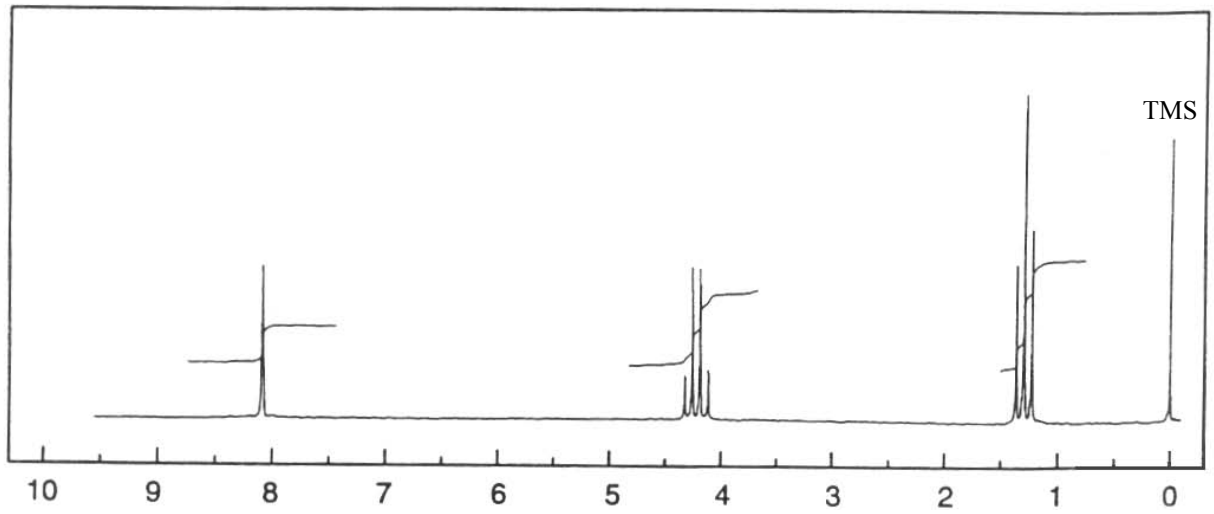
$1750\ cm^{-1}$ . . . . . .

$1180\ cm^{-1}$ . . . . . .

(This question continues on the following page)

(Question G1 continued)

(d) The ^{1}H NMR spectrum of compound **C** is shown below.



(i) The shifts centred at 1.3 and 4.3 ppm are split into a triplet and a quartet respectively. State what information about the structure of compound **C** can be deduced from these splitting patterns. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) State what can be deduced about the chemical environment of the proton responsible for the singlet at 8.0 ppm. *[1]*

. . . . . .

. . . . . .

(This question continues on the following page)

(Question G1 continued)

(e) (i) Deduce the structural formula and name of compound **C**. *[2]*

(ii) Compound **A** shows two singlets in its ^{1}H NMR spectrum, while compound **B** shows one singlet, one triplet and one quartet. Deduce the names of compounds **A** and **B**. *[2]*

Compound **A** . . . . . .

Compound **B** . . . . . .

G2. (a) Explain the principles of operation of an X-ray diffractometer and show how the Bragg equation can be derived. *[6]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) In a particular crystal the maximum constructive interference is obtained using X-rays of wavelength 1.54×10^{-10} m when the angle of incidence is $11.0\,°$. Calculate the distance between the layers in the crystal. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

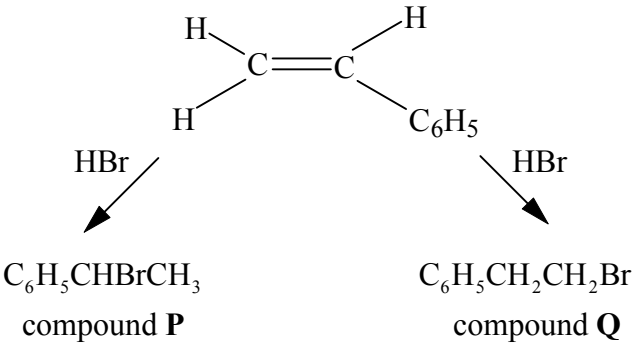
. . . . . .

. . . . . .

Blank page

Option H – Further organic chemistry

H1. Phenylethene (styrene) reacts with hydrogen bromide to give compound **P** as the major product and compound **Q** as the minor product.



(a) (i) State the name of the mechanism of this reaction. *[1]*

. . . . . .

(ii) Write a mechanistic equation, using "curly arrows" to show the movement of electron pairs, for the first step of this mechanism. *[1]*

(iii) Draw the structures of the two intermediate carbocations formed. *[2]*

(iv) Explain why compound **P** is the major product of the reaction. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question H1 continued)

(b) (i) Compound **P** can exist as two stereoisomers. Draw structures for both of these isomers, showing clearly the difference between them. *[2]*

(ii) State what differences, if any, there are in the physical and chemical properties of the two stereoisomers of compound **P**. *[2]*

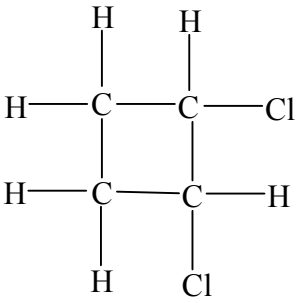
Physical . . . . . .

. . . . . .

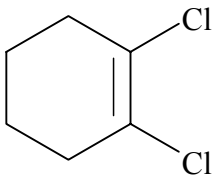
Chemical . . . . . .

. . . . . .

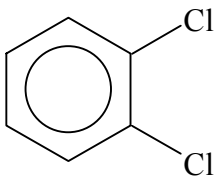
H2. Identify which **two** of the following compounds can exist as geometrical isomers, and explain your choice. *[3]*



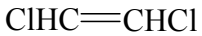
W



X



Y



Z

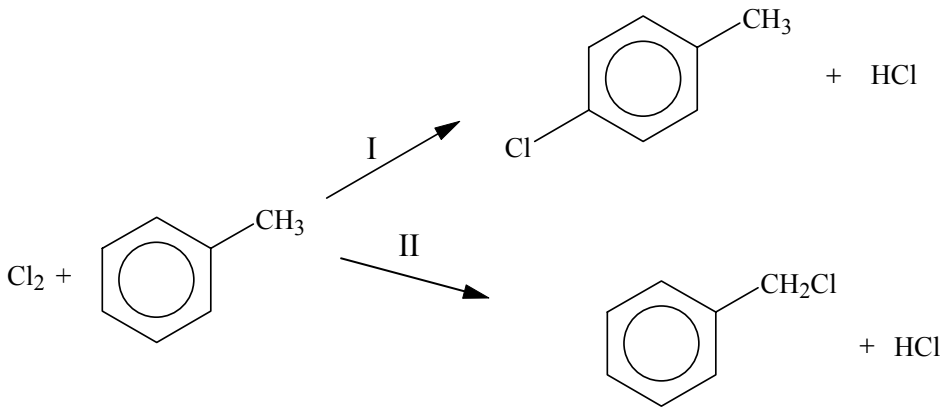
. . . . . .

. . . . . .

. . . . . .

. . . . . .

H3. Chlorine can react with methylbenzene to give different organic products, depending on the reaction conditions.



(a) For each reaction, state the conditions needed and give the stepwise mechanism. *[8]*

I . . . . . .

II . . . . . .

(This question continues on the following page)

(Question H3 continued)

(b) Phenol can also react with chlorine in a similar way to one of the reactions above. State and explain whether phenol is more reactive or less reactive than methylbenzene, and give the structural formula of the final organic product. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .