INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
BACHILLERATO INTERNACIONAL

N99/420/H(3)

CHEMISTRY

Higher Level

Wednesday 17 November 1999 (morning)

Paper 3

1 hour 15 minutes

A

Candidate name:	Candidate category & number:

This examination paper consists of 6 Options.
The maximum mark for each option is 25.
The maximum mark for this paper is 50.

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.

At the end of the examination, complete box B below with the letters of the options answered.

B

OPTIONS ANSWERED

C

EXAMINER	TEAM LEADER
/25	/25
/25	/25
TOTAL /50	TOTAL /50

D

IBCA
/25
/25
TOTAL /50

EXAMINATION MATERIALS

Required:
Calculator
Chemistry Data Booklet

Allowed:
A simple translating dictionary for candidates not working in their own language

Option C – Human Biochemistry

C1. The structures of vitamin A (retinol) and vitamin C (ascorbic acid) are given in Table 21 of the Data Booklet.

(a) Name **two** functional groups which are present in retinol.

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(b) By referring to the structures, classify vitamin A and vitamin C as water or fat soluble and account for the difference on the molecular level.

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(c) State **one** physical symptom of each of vitamin A and vitamin C deficiency. State the common name given to vitamin C deficiency.

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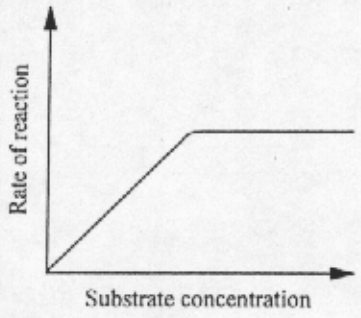
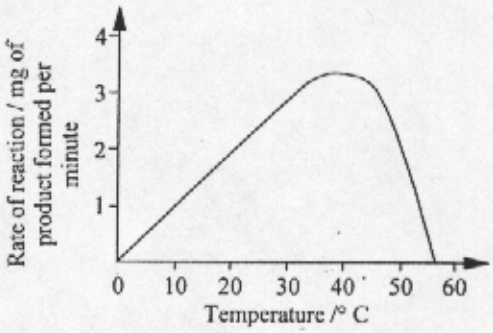
C2. (a) List the **three** major functions of fats in the body. Write a general formula for a fat or an oil and describe the structural similarity between the two. State how the molecular structures of a fat and an oil differ and explain why one is a solid at room temperature and the other a liquid. *[8]*

(b) 0.014 moles of a particular oil was found to react exactly with 14.2 g of iodine. Calculate the number of moles of iodine that reacted and state what can be deduced about the structure of the oil from this information. *[3]*

C3. The two graphs below illustrate how the concentration of substrate and the temperature can both affect the rate of enzyme-catalysed reactions:



Graph of rate of reaction against substrate concentration



Graph of rate of reaction against temperature

(a) Explain why the rate of reaction:

(i) initially increases as the substrate concentration increases. [

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(ii) remains constant after a certain substrate concentration has been reached. [

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(iii) increases as the temperature increases from 0° C to 40° C. [

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(iv) falls to zero at temperatures above 57° C. [

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(b) Apart from substrate concentration and temperature, state **two** other factors which affect the rate of enzyme catalysed reactions. [2

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Option D – Environmental Chemistry

D1. Carbon dioxide is perhaps the best known greenhouse gas. What is the greenhouse effect? Identify **one** other greenhouse gas and explain how these gases contribute to this effect. Explain how particulates can counteract this effect. *[5]*

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D2. (a) Apart from removing disease-causing agents, state **two** types of impurities which are removed during the treatment of fresh water for drinking purposes.

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(b) Describe the primary, secondary and tertiary stages of sewage treatment. State the pollutants removed at each stage, discuss the effectiveness of each stage of sewage treatment and state why there is an increasing need for tertiary treatment.

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D3. The two oxygen–oxygen bonds in ozone are of equal length. Draw two Lewis structures to account for this fact, and use these to explain the dependence of the dissociation of oxygen and ozone on the wavelength of light. [4

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D4. Identify **two** primary pollutants of photochemical smog and state the main source of these pollutants. Explain with the aid of equations how the primary pollutants produce ozone. Describe the role of sunlight in this process. [6

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Option E – Chemical Industries

E1. For each of the classes of manufactured chemicals listed below, name **one** of the chemicals and give an example of its use. *[6]*

Example:

Acids: Sulphuric acid is used in the manufacture of detergents.

(a) Alloys: .....

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(b) Polymers: .....

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(c) Chloro-alkali products: .....

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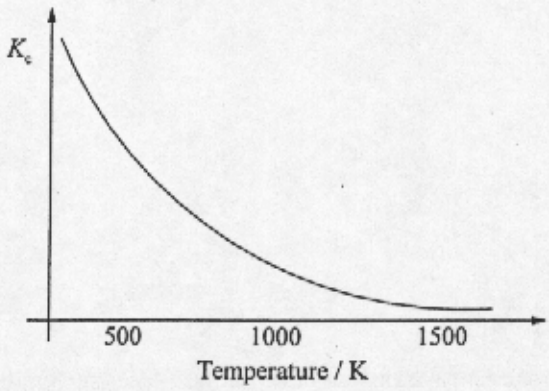
E2. The graph below (not to scale) indicates the variation of K_c with temperature for an industrial process:



(a) Based on the graph, explain whether the reaction is exothermic or endothermic. *[2*

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(b) Industrially, this process is carried out at 750 K. Explain why it is not carried out at a much higher or much lower temperature. State how a catalyst could increase the rate of this reaction at 750 K. *[3*

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E3. Catalytic cracking is one of the processes that takes place in an oil refinery. Explain the purpose of this process and state why it is important. Write a balanced equation using molecular formulas to represent a typical example of the process. In addition to a catalyst, state what other condition is necessary for the process. Identify an appropriate catalyst and outline a mechanism for the reaction. *[10]*

E4. n-type and p-type semiconductors can be produced by adding very small amounts of different elements to highly purified silicon. In each case identify an element that could be added to produce each type of semiconductor and describe how it achieves its purpose. *[4]*

Option F – Fuels and Energy

F1. (a) Describe how coal and oil were formed. *[2]*

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(b) Two possible reactions of coal are given below with their associated enthalpy changes per mole of product:

$$C(s) + \tfrac{1}{2}O_2(g) \rightarrow CO(g) \qquad \Delta H = -111 \text{ kJ}$$
$$C(s) + 2H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow CH_3OH(l) \qquad \Delta H = -239 \text{ kJ}$$

(i) From this information, calculate the heat of reaction for: *[2]*

$$CO(g) + 2H_2(g) \rightarrow CH_3OH(l)$$

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(ii) Give a balanced equation for the complete combustion of methanol. *[1]*

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(iii) Use information provided in Table 2 of the Data Booklet to calculate the amount of heat required to raise the temperature of 500 kg of water at 25.0° C to water at 100.0° C. *[1]*

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(iv) Use information provided in Table 13 of the Data Booklet to calculate the mass of methanol that must be burnt completely to produce the amount of heat required in (iii). *[2]*

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F2. (a) ^{234}Pa decays by beta emission. Give a balanced equation for the nuclear reaction. *[1]*

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(b) The half-life of ^{234}Pa is approximately 70 s. What fraction of a sample's initial activity will be present after 350 s? *[1]*

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F3. List **three** possible stages at which radioactive materials might escape from a nuclear power plant, and **two** ways in which such escapes might be prevented. *[5]*

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F4. (a) Explain why the actual mass of a nucleus is slightly less than the sum of the masses of its protons and neutrons. *[1]*

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(This question continues on the following page)

(Question F4 continued)

(b) Given the following relative isotopic masses, calculate the energy evolved when one gram of ^{235}U undergoes the following reaction: *[4]*

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{144}_{56}Ba + {}^{90}_{36}Kr + 2{}^{1}_{0}n$$

$$^{235}_{92}U = 235.0439;\ {}^{144}_{56}Ba = 143.8810;\ {}^{90}_{36}Kr = 89.9470;\ {}^{1}_{0}n = 1.0087$$

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F5. (a) State the trend in the neutron to proton ratio for stable nuclei with increasing atomic number, and give a reason for this behaviour. *[3]*

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(b) Explain why elements above atomic number 83 with mass number 209 do not exist as stable isotopes. *[1]*

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(c) If a radionuclide has a lower n to p ratio than for a stable nuclei, give a balanced nuclear equation to represent what happens. *[1]*

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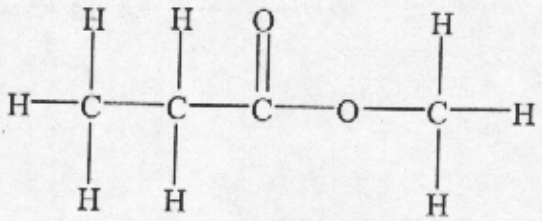
Option G – Modern Analytical Chemistry

G1. Consider the ^1H NMR (nuclear magnetic resonance) spectrum that you would expect from methyl propanoate, shown below:



(a) Hydrogen atoms within a molecule can exist in different chemical environments. How many different types of hydrogen atoms are there in the molecule?

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(b) Use Table 19 of the Data Booklet and the structure of the molecule to complete the following table about the nature of the spectrum you would expect. (Note, you may not need all of the available spaces.)

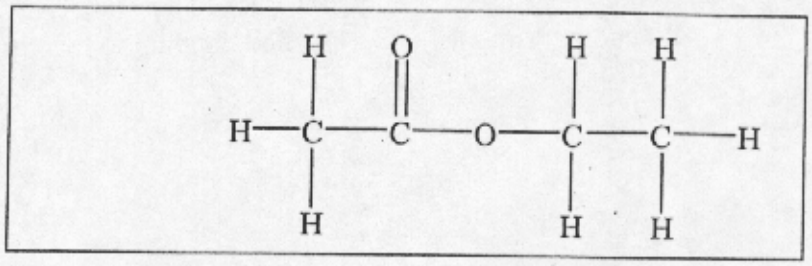
Type of Hydrogen	Chemical shift ppm	Area under peak(s) (area for one H atom = 1)	Splitting (singlet, doublet *etc.*)
1			
2			
3			
4			
5			

(This question continues on the following page)

(Question G1 continued)

(c) Methyl propanoate has a number of isomers. For each of the following isomers state **one** difference in the ^1H NMR spectrum that would allow you to distinguish it from methyl propanoate. *[3]*

(i) ethyl ethanoate



difference: .....

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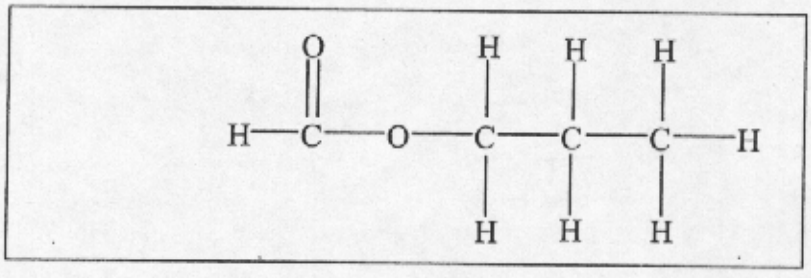
(ii) propyl methanoate



difference: .....

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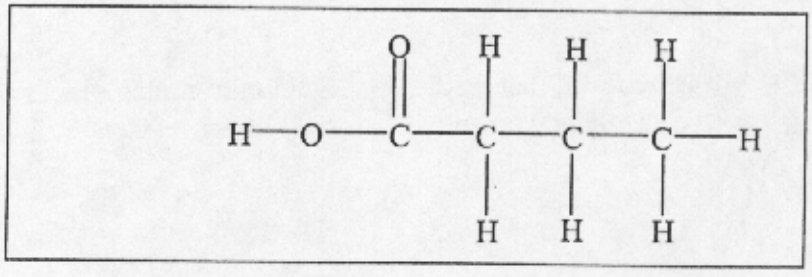
(iii) butanoic acid



difference: .....

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(iv) Identify which **one** of the four isomers can be distinguished from the other three using infra-red spectroscopy, and describe how its spectrum would differ. *[2]*

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G2. Chromatography is a very powerful tool in each of the following situations. State which chromatographic technique could be used to solve each problem. Describe briefly how the technique could be carried out and the results interpreted:

(a) It is suspected that the colouring matter used to dye a food product is a mixture, one component of which may be a banned substance. A pure sample of the banned substance is available. You may use a labelled diagram to help if you wish. [

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(b) It is believed that an organic liquid may contain traces of ethanol. The quantity of ethanol, if any, is to be determined. [4]

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Option H – Further Organic Chemistry

H1. Compound *A*, an organic acid, has the molecular formula $C_5H_8O_2$. This compound can exist as two geometric isomers, cis-A and trans-A, each containing two methyl groups.

(a) Give the structural formulas of the two geometric isomers. *[2]*

(b) When hydrogen gas is added to the cis-isomer, a racemic mixture of an alkanoic acid *B* is obtained. The same racemic mixture is also obtained when hydrogen gas is added to the trans-isomer. Write the equation for the hydrogenation of cis-A or trans-A isomer to form *B*. *[1]*

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(c) Name *B*. *[1]*

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(d) Explain what is meant by a racemic mixture. *[1]*

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(e) Under certain conditions, the racemic mixture could be separated into two optically active enantiomers, *C* and *D*. Give the structural formulas of the enantiomers *C* and *D*. *[2]*

(f) Describe the similarities and the difference in the physical properties of enantiomers. *[2]*

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H2. (a) With reference to Table 16 in the Data Booklet, rank the following compounds in order of increasing acid strength (weakest one first). Explain the order on the molecular level: *[4]*

ethanol, phenol, 4-nitrophenol

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(b) Compare the acidity of ethanol to that of water and account for the difference. *[2]*

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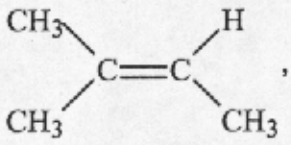
H3. (a) For the addition of bromine to  , name and outline the mechanism of the reaction. *[4]*

(b) When hydrogen bromide reacts with the alkene in (a) above, there are two possible products. Give the structural formulas of the two products. *[2]*

(c) Give the structures of the two carbocations (carbonium ions) which could, in theory, be formed at the first stage of the reaction with HBr. Identify the major product and explain why it is formed in the larger amount. *[4]*