INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
BACHILLERATO INTERNACIONAL

CHEMISTRY
STANDARD LEVEL
PAPER 3

Wednesday 14 November 2001 (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 three 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
		/15	/15	/15
		/15	/15	/15
		/15	/15	/15
NUMBER OF CONTINUATION BOOKLETS USED	. . . .	TOTAL /45	TOTAL /45	TOTAL /45

Option A – Higher organic chemistry

A1. (a) Use the valence shell electron pair repulsion (VSEPR) theory to complete the following table. *[3]*

Molecule	Number of electron pairs around the central (underlined) atom	Shape of molecule
$\underline{B}Cl_3$		
$H_2\underline{S}$		

(b) (i) State how the VSEPR theory can be extended to compounds or ions with a double or triple bond around the central atom or ion. *[1]*

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(ii) State the shape of the following three species: *[3]*

1. HCN . . . .

2. XeF_4 . . . .

3. SO_3^{2-} . . . .

A2. 1-bromobutane, $CH_3CH_2CH_2CH_2Br$, and 2-bromo-2-methylpropane, $(CH_3)_3CBr$, can both react with a warm, dilute solution of sodium hydroxide to form the corresponding alkanols.

(a) Name and outline the mechanism for each reaction. *[6]*

(i) $CH_3CH_2CH_2CH_2Br$ . . . .

(This question continues on the following page)

(Question A2(a) continued)

(ii) $(CH_3)_3CBr$ . . . .

(b) Both of the above halogenoalkanes can also react in a similar way with aminoethane, $C_2H_5NH_2$. State, with a reason, which of the two halogenoalkanes will react faster and write a balanced equation for the reaction taking place. *[2]*

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Option B – Higher physical chemistry

B1. (a) Magnesium carbonate decomposes according to the equation:

$$MgCO_3(s) \rightarrow MgO(s) + CO_2(g) \quad \Delta H^{\ominus} = +100.3 \text{ kJ mol}^{-1}$$

The quantitative value for $\Delta S^{\ominus}$ for this reaction is 174.8 J $K^{-1}mol^{-1}$

(i) Explain whether the value for $\Delta S^{\ominus}$ is positive or negative by referring to the equation above. *[2]*

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(ii) Calculate $\Delta G^{\ominus}$ for this reaction at 298K. *[2]*

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(iii) State whether or not this reaction is spontaneous at 298K and calculate the temperature at which the reaction becomes spontaneous. *[2]*

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(b) Explain why some reactions that are spontaneous at 298K still need to be heated before they will proceed. *[1]*

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B2. (a) The following experimental data was obtained for the reaction between hydrogen and nitrogen(II) oxide at $800^{\circ}C$.

Experiment	Initial concentration of H_2 / mol dm^{-3}	Initial concentration of NO / mol dm^{-3}	Initial rate / mol $dm^{-3}s^{-1}$
1	6.00×10^{-3}	1.00×10^{-3}	5.00×10^{-4}
2	6.00×10^{-3}	2.00×10^{-3}	2.00×10^{-3}
3	6.00×10^{-3}	3.00×10^{-3}	4.50×10^{-3}
4	3.00×10^{-3}	3.00×10^{-3}	2.25×10^{-3}

The equation for the reaction is:

$$2H_2(g) + 2NO(g) \rightarrow 2H_2O(g) + N_2(g)$$

(i) Deduce the order of reaction with respect to H_2. *[1]*

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(ii) Deduce the order of reaction with respect to NO. *[1]*

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(iii) State the rate expression for the reaction. *[1]*

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(iv) Calculate the value for the rate constant and state the units. *[2]*

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(b) (i) Calculate the initial rate for the above reaction when the initial values for the concentrations of H_2 and NO are both 5.00×10^{-3} mol dm^{-3}. *[1]*

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(This question continues on the following page)

(Question B2(b) continued)

(ii) A proposed mechanism for the reaction is:

Step 1: $NO(g) + NO(g) \rightarrow N_2O_2(g)$

Step 2: $N_2O_2(g) + H_2(g) \rightarrow H_2O(g) + N_2O(g)$

Step 3: $N_2O(g) + H_2(g) \rightarrow N_2(g) + H_2O(g)$
(Step 3 is known to be a fast step.)

Identify whether Step 1 or Step 2 is the slow step in this mechanism and explain your answer. *[2]*

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Option C – Human biochemistry

C1. In order to determine the enthalpy change of combustion of peanut oil, a peanut was weighed, then ignited and the flame used to heat a test tube containing 10.0 g of water. After burning, the peanut was weighed again. The results obtained were as follows:

Mass of peanut before burning	=	2.063 g	Initial temperature of water	=	17.4°C
Mass of peanut after burning	=	1.568 g	Final temperature of water	=	62.6°C

(a) Assuming that the specific heat capacity of water is $4.18\ \text{J g}^{-1}\,{}^{\circ}\text{C}^{-1}$, calculate the heat gained by the water. *[2]*

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(b) Using your answer to (a), calculate a value for the enthalpy of combustion (in kJ g^{-1}) of peanut oil. *[1]*

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(c) The major flammable component of the peanut is the oil it contains. Draw the structural formula of a typical oil, representing the hydrocarbon chains by "R". *[2]*

(d) A more accurate value for the enthalpy of combustion of peanut oil is $25.0\ \text{kJ g}^{-1}$. State **two** reasons for the difference in the values. *[2]*

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(This question continues on the following page)

(Question C1 continued)

(e) Suggest **two** ways to improve the experiment in order to obtain a more accurate answer. *[2]*

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C2. (a) State the empirical formula of a monosaccharide and list the number and types of functional groups common to all monosaccharides. *[3]*

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(b) Draw the straight-chain structural formula of glucose. *[1]*

(c) The enthalpy change of combustion of glucose is given in the Data Booklet (Table 13). Calculate the energy that can be obtained from 1.00 g of glucose. *[1]*

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(d) Explain why significantly less energy is obtained per gram from sugars such as glucose than is obtained from oils such as peanut oil. *[1]*

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Option D – Environmental chemistry

D1. (a) It is now generally accepted that global warming is occurring. State **two** pieces of evidence to support this. *[2]*

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(b) Name **one** greenhouse gas apart, from carbon dioxide, that contributes to global warming. *[1]*

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(c) Using carbon dioxide as an example, explain how greenhouse gases contribute to global warming. *[3]*

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(d) The combustion of hydrocarbon fuels produces particulates. Explain how particulates in the atmosphere can affect the Earth's surface temperature. *[1]*

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D2. The high temperature inside a car engine causes a reaction between nitrogen and oxygen to form oxides of nitrogen.

(a) Explain why the reaction between nitrogen and oxygen only takes place at high temperatures. *[1]*

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(b) The emission of nitrogen oxides from car exhausts can be reduced by using a catalytic converter.

(i) State one metal used as a catalyst in a catalytic converter. *[1]*

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(ii) Give an equation to show how nitrogen monoxide, NO, reacts in a catalytic converter. *[2]*

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(iii) State and explain **one** other method that can be used to reduce NO_x emissions from a car engine. *[2]*

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(c) Nitrogen oxides can react to form nitric acid in the air. Nitric acid is one of the acids present in acid rain.

(i) State the other main primary pollutant which also reacts to form acid rain in the air. *[1]*

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(ii) Give the equation for the reaction of nitric acid with limestone, $CaCO_3$. *[1]*

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Option E – Chemical industries

E1. (a) Common ores of iron include haematite (Fe_2O_3), magnetite (Fe_3O_4) and iron pyrites (FeS_2). Iron may be extracted from the oxide ores in a blast furnace.

(i) Suggest an environmental reason why iron is not usually extracted from iron pyrites. *[1]*

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(ii) Iron ore is usually formed into small pellets before it is added to the blast furnace. State a reason for this. *[1]*

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(b) Coke is added to the blast furnace with the iron ore.

(i) Give the equation for the reaction involving coke that is used to maintain the high temperature of the blast furnace. *[1]*

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(ii) Give the equation for the reaction involving coke that is used to produce the main reducing agent in the blast furnace. *[1]*

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(iii) Give the equation for the reaction of magnetite with the reducing agent in (b)(ii). *[1]*

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(c) Limestone, $CaCO_3$, is used in the blast furnace to remove impurities as slag.

(i) State **two** impurities that are removed. *[2]*

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(ii) Give an equation for the reaction that limestone on its own undergoes at high temperatures. *[1]*

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(iii) Give an equation for the formation of slag from **one** of the impurities that you have stated in (c)(i). *[1]*

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(iv) State **one** use for slag. *[1]*

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E2. (a) The iron formed in the blast furnace contains impurities that are later removed in the steel making process.

(i) State **two** effects that these impurities have on the properties of the iron. *[2]*

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(ii) State how these impurities are removed during the steel making process. *[1]*

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(b) Name a metal that is added to iron in the steel making process, and state a use for the alloy formed. *[2]*

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Option F – Fuels and energy

F1. Many cars run on a mixture of gasoline (petrol) and ethanol called 'gasohol'. The gasoline is obtained from crude oil and the ethanol from the fermentation of carbohydrates.

(a) The higher boiling fractions of crude oil can be cracked catalytically to produce gasoline.

(i) Give an equation to show the cracking of $C_{18}H_{38}$ to produce octane C_8H_{18}. *[1]*

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(ii) Apart from producing gasoline, state why cracking is so important to industry. *[1]*

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(b) Give the equation for the fermentation of glucose, $C_6H_{12}O_6$ to form ethanol. *[1]*

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(c) The enthalpy changes of combustion for octane and ethanol are given in the Data Booklet (Table 13).

(i) Write the equations for the complete combustion of octane and ethanol. *[2]*

Octane: . . . .

Ethanol: . . . .

(ii) Calculate the heat given out when 1.00 kg of octane is burned and when 1.00 kg of ethanol is burned. *[3]*

Octane: . . . .

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Ethanol: . . . .

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(iii) Explain why many cars use 'gasohol' rather than normal gasoline. *[1]*

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F2. (a) State **two** reasons why coal is sometimes converted into gaseous and liquid fuels. *[2]*

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(b) Coke can be made into a mixture of liquid hydrocarbons by first converting it to synthesis gas, then reacting the synthesis gas with steam in a catalysed fluid bed reactor.

(i) State how coke is obtained from coal. *[1]*

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(ii) State the conditions used to turn coke into synthesis gas. *[2]*

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(iii) One of the components of synthesis gas is carbon monoxide. Name the other gas present in synthesis gas. *[1]*

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