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

M03/420/S(3)

CHEMISTRY
STANDARD LEVEL
PAPER 3

Candidate number

Thursday 15 May 2003 (morning)

1 hour

INSTRUCTIONS TO CANDIDATES

- Write your candidate number in the box 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 candidate number on each answer sheet, and attach them to this examination paper 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 A – Higher physical organic chemistry

A1. The compounds with the molecular formula C_4H_9Br all undergo nucleophilic substitution reactions when warmed with sodium hydroxide solution. The equation for each of the reactions is

$$C_4H_9Br + OH^- \rightarrow C_4H_9OH + Br^-$$

When the reaction of one of these compounds was investigated the following kinetic data were obtained.

Experiment number	Initial $[C_4H_9Br]$ / mol dm^{-3}	Initial $[OH^-]$ / mol dm^{-3}	Initial rate of reaction / mol dm^{-3} min^{-1}
1	0.010	0.010	2.0×10^{-3}
2	0.020	0.010	4.0×10^{-3}
3	0.020	0.020	4.0×10^{-3}

(a) Explain the term *nucleophilic substitution*. *[2]*

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(b) Deduce the order of reaction with respect to C_4H_9Br. *[1]*

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(c) Deduce the order of reaction with respect to OH^- and explain your answer. *[2]*

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

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(e) Calculate the value of the rate constant for the reaction and state its units. *[2]*

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(This question continues on the following page)

(Question A1 continued)

(f) Give the equations for the mechanism of this reaction. *[2]*

(g) Define the term *rate-determining step* and identify this step in the mechanism. *[2]*

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(h) Define the term *molecularity* and deduce its value in the mechanism. *[2]*

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A2. Propanoic acid, CH_3CH_2COOH, is a weak acid.

(a) Give the equation for the ionization of propanoic acid in water and deduce the expression for the ionization constant, K_a, of propanoic acid. *[2]*

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(b) Calculate the K_a value of propanoic acid using the pK_a value in the Data Booklet. *[1]*

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(c) Use your answer from (b) to calculate the $[H^+]$ in an aqueous solution of propanoic acid of concentration 0.0500 mol dm^{-3}, and hence the pH of this solution. *[3]*

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Option B – Medicines and drugs

B1. (a) Many drugs are taken orally. State **three** other ways in which drugs may be taken by a patient. *[2]*

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(b) State what is meant by the term *side effect*. *[1]*

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(c) One common type of drug taken orally is the antacid. Antacids such as sodium hydrogencarbonate are taken to reduce stomach acidity.

(i) State the names of **two** metals, other than sodium, whose compounds are often used in antacids. *[1]*

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(ii) Give an equation for the neutralization of hydrochloric acid in the stomach by sodium hydrogencarbonate. *[1]*

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(iii) Explain how heartburn is caused. *[1]*

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(iv) Explain why dimethicone is added to some antacids. *[1]*

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B2. (a) (i) State what is meant by the term *analgesic*. Explain the difference in the mode of action of mild and strong analgesics. *[3]*

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(ii) State the general names of the **two** functional groups attached to the benzene ring in a molecule of aspirin. *[2]*

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(iii) The use of aspirin can have beneficial effects for the user, but can also produce some unwanted side effects. State **one** beneficial effect (other than its analgesic action) and **one** unwanted side effect. *[2]*

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(b) Morphine is a naturally occurring analgesic that can be converted into codeine.

(i) Calculate the difference in relative formula mass between morphine and codeine. *[1]*

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(ii) Explain what is meant by developing tolerance towards codeine and state why this is dangerous. *[2]*

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B3. The breathalyser can be used to detect ethanol in breath. Explain how this can be done, by reference to the substance used, the colour change and the type of reaction occurring. *[3]*

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Option C – Human biochemistry

C1. Polypeptides and proteins are formed by the condensation reactions of amino acids.

(a) Give the general structural formula of a 2-amino acid. *[1]*

(b) Give the structural formula of the dipeptide formed by the reaction of alanine and glycine. State the other substance formed during this reaction. *[2]*

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(c) State **two** functions of proteins in the body. *[2]*

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(This question continues on the following page)

(Question C1 continued)

(d) Electrophoresis can be used to identify the amino acids present in a given protein. The protein must first be hydrolyzed.

(i) State the reagent and conditions needed to hydrolyze the protein, and identify the bond that is broken during hydrolysis. *[4]*

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(ii) Explain how the amino acids could be identified using electrophoresis. *[4]*

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C2. Fats and oils can be described as esters of glycerol, $C_3H_8O_3$.

(a) (i) Draw the structure of glycerol. *[1]*

(ii) Glycerol can react with three molecules of stearic acid, $C_{17}H_{33}COOH$, to form a triglyceride. Deduce the number of carbon atoms in one molecule of this triglyceride. *[1]*

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(iii) A triglyceride is also formed in the reaction between glycerol and three molecules of oleic acid, $C_{17}H_{33}COOH$. State and explain which of the two triglycerides (the one formed from stearic acid or the one formed from oleic acid) has the higher melting point. *[3]*

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(b) An oil sample containing 0.0100 mol of oil was found to react with 7.61 g of iodine, I_2. Determine the number of C=C double bonds present in each molecule of the oil. *[2]*

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Option D – Environmental chemistry

D1. The demand for drinking water continues to be a problem for the world. About 97 % of all the water on the planet is present in the seas and oceans and most of the rest is in ice caps or glaciers.

(a) One method used to provide drinking water from sea water is reverse osmosis, which uses a partially permeable (semipermeable) membrane.

(i) Outline the terms *osmosis* and *partially permeable membrane.* *[2]*

Osmosis:

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Partially permeable membrane:

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(ii) Explain the technique of reverse osmosis used to produce drinking water from sea water. *[3]*

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(iii) Suggest **one** way in which a householder could reduce the amount of water used. *[1]*

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(This question continues on the following page)

(Question D1 continued)

(b) Water that allows marine life to flourish needs a high concentration of dissolved oxygen. Several factors can alter the oxygen concentration.

(i) State how an increase in temperature affects the oxygen concentration. *[1]*

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(ii) Eutrophication is a process that decreases the oxygen concentration of water. Explain how the accidental release of nitrates into a river can cause eutrophication. *[2]*

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(c) Much drinking water is treated before use with either chlorine or ozone. State **two** advantages and **two** disadvantages of using ozone instead of chlorine. *[4]*

Advantages: . . . . . .

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Disadvantages: . . . . . .

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D2. Waste water (sewage) from homes and industries varies greatly in its content, but it is desirable to treat it before it is returned to the environment, especially to reduce the Biological Oxygen Demand (BOD).

(a) State what is meant by the term *Biological Oxygen Demand*. *[2]*

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(b) Describe the main features of the activated sludge process used in secondary treatment, and state the main impurities removed during this treatment. *[5]*

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Option E – Chemical industries

E1. The oil industry converts most crude oil into fuels using several different processes, including fractional distillation, cracking and reforming.

(a) Describe and explain how crude oil is converted into several fractions in a fractionating column. *[4]*

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(b) All methods of cracking use high temperatures, but the other conditions vary, depending on the types of product required.

(i) State the name of a catalyst used in catalytic cracking. Write an equation for the cracking of the straight-chain molecule $C_{14}H_{30}$ into **two** products, assuming that only the central C–C bond breaks. *[2]*

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(ii) Hydrocracking is used to produce high-grade gasoline. Name the substance added to the feedstock and state **one** characteristic structural feature of the hydrocarbons produced. *[2]*

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(c) One type of reforming is called aromatization. Write an equation for this process, starting with hexane. State **one** use for the inorganic product formed. *[2]*

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E2. Several monomers are produced by the oil industry and used in polymer manufacture. Examples include propene, styrene and vinyl chloride.

(a) (i) Draw the structural formula of propene. *[1]*

(ii) Isotactic polypropene has a regular structure, while atactic polypropene does not. Draw the structure of isotactic polypropene, showing a chain of at least six carbon atoms. State and explain how its properties differ from those of atactic polypropene. *[3]*

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(b) Styrene can be polymerized to polystyrene, which is a colourless, transparent, brittle plastic. Another form of the polymer is expanded polystyrene. Outline how expanded polystyrene is produced from polystyrene, and state how its properties differ from those of polystyrene. *[4]*

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(Question E2 continued)

(c) Many plastic materials are disposed of by combustion. State **two** disadvantages of disposing of polyvinyl chloride in this way. *[2]*

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Option F – Fuels and energy

F1. Coal is the world's most abundant fossil fuel, although its combustion can cause problems of pollution. As well as carbon, coal may contain significant amounts of sulfur and non-combustible inorganic material.

(a) Describe the conditions under which coal was formed from plant remains. *[3]*

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(b) State **three** pollutants formed when coal is burned directly. *[2]*

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(c) One way to reduce the amount of pollution is to convert the coal to a gaseous fuel by heating with steam.

(i) State the **two** combustible products of the reaction. *[2]*

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(ii) Outline **two** advantages and **one** disadvantage of coal gasification. *[3]*

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F2. Many portable electrical devices rely on various types of dry cell. The most common is the zinc-carbon cell, although alkaline cells are becoming more common.

(a) In the zinc-carbon cell, the space between the central carbon rod and the zinc outer casing is filled with a paste containing ammonium chloride and manganese(IV) oxide.

(i) One reaction occurring is $2NH_4^+ + 2e^- \rightarrow 2NH_3 + H_2$, for which $E^\ominus = +0.73$ V. Use the Data Booklet to identify the other main reaction occurring, and hence determine the $E^\ominus$ value for the cell. Write the overall cell reaction. *[2]*

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(ii) State the purpose of the manganese(IV) oxide. *[1]*

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(b) State **two** advantages of the alkaline cell over the zinc-carbon cell. *[2]*

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(c) A company manufactures a cell with a voltage of about 1.5 V. Suggest how the company could make each of the following.

(i) A cell with a voltage of about 1.5 V, but producing more power. *[1]*

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(ii) A battery with a voltage of about 6 V. *[1]*

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F3. Fuel cells have been described as the energy source of the future, because they are said to be non-polluting and can use renewable resources. One type uses hydrogen as the fuel and oxygen as the other substance consumed, with hot aqueous potassium hydroxide as the electrolyte. The overall equation for the process is $2H_2 + O_2 \rightarrow 2H_2O$, but the actual reactions taking place are different.

(a) Give the **two** half-equations for the reactions involving each reactant. *[2]*

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(b) Each kilojoule of chemical energy released in the oxidation of hydrogen in the fuel cell costs more than that released in the combustion of gasoline. Explain why fuel cells are considered to be more economical than gasoline engines. *[1]*

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