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

N04/4/CHEMI/SP3/ENG/TZ0/XX

88046106

CHEMISTRY
STANDARD LEVEL
PAPER 3

School code

Candidate code

Thursday 18 November 2004 (morning)

1 hour

INSTRUCTIONS TO CANDIDATES

- Write your school code and candidate code 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 school code and candidate code 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. There are two alcohols, **A** and **B**, with molecular formula C_3H_8O. The following information was obtained from a mass spectrum of each alcohol.

A: peaks at m/z = 29, 31, 60

B: peaks at m/z = 45, 60

(a) Write the formula for the species responsible for the peak at m/z = 60. *[1]*

. . . . . .

(b) Deduce the formula of the species with m/z = 31. *[1]*

. . . . . .

(c) Deduce the structures of the **two** alcohols. *[2]*

Structure of **A**

Structure of **B**

(d) The peak at m/z = 45 is more prominent than that at m/z = 29. Suggest a reason for this. *[1]*

. . . . . .

. . . . . .

(This question continues on the following page)

(Question A1 continued)

(e) The ^{1}H NMR spectrum of one of the alcohols shows four peaks with areas in the ratio 3:2:2:1.

(i) State what can be deduced from this information. *[2]*

Four peaks

. . . . . .

. . . . . .

Areas in ratio 3:2:2:1

. . . . . .

. . . . . .

(ii) Predict the number of peaks, and the ratio of their areas, in the ^{1}H NMR spectrum of the other alcohol. *[2]*

. . . . . .

. . . . . .

. . . . . .

A2. Gaseous hydrogen iodide, HI, decomposes into its elements when heated. The decomposition was investigated in a series of experiments carried out at the same temperature. The following data was obtained.

Experiment number	Initial [HI] / mol dm^{-3}	Initial rate of reaction / mol dm^{-3} s^{-1}
1	2.2×10^{-3}	1.1×10^{-6}
2	6.6×10^{-3}	9.9×10^{-6}
3	2.2×10^{-2}	1.1×10^{-4}
4	4.4×10^{-3}	to be determined

(a) Write the equation for the decomposition of hydrogen iodide. *[1]*

. . . . . .

(b) Deduce the order of the reaction and explain your answer. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

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

. . . . . .

(d) Determine the initial rate of reaction in experiment 4. *[1]*

. . . . . .

. . . . . .

(e) Define the term *molecularity* and deduce its value in this reaction. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

A3. The formula and pK_a value of chloroethanoic acid appear in Table 16 of the Data Booklet. Use this information to answer the following questions.

(a) Write the equation for the dissociation of chloroethanoic acid in aqueous solution. *[1]*

. . . . . .

(b) Deduce the K_a expression for the dissociation. *[1]*

. . . . . .

. . . . . .

(c) Calculate the value of K_a for chloroethanoic acid. *[1]*

. . . . . .

. . . . . .

(d) Arrange the following acids in increasing order of acid strength (starting with the weakest). *[1]*

chloroethanoic acid ethanoic acid iodoethanoic acid

Order . . . . . .

Option B – Medicines and drugs

B1. Depressants such as tranquilizers and sedatives are capable of affecting the central nervous system.

(a) State **two** effects, in **each** case, on the body of taking

(i) a low dose of a tranquilizer. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) a high dose of a sedative. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Explain why depressants are sometimes described as anti-depressants. *[1]*

. . . . . .

. . . . . .

(c) The most widely-used depressant is ethanol. Discuss the harmful effects of regularly taking large amounts of ethanol by referring to **four** specific problems. *[4]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question B1 continued)

(d) List **two** depressants whose structures are shown in Table 21 of the Data Booklet. *[1]*

. . . . . .

. . . . . .

(e) One problem with many drugs is that users develop *tolerance*. Explain what is meant by the term *tolerance* and state why it could increase the risk to the user. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

B2. Caffeine and nicotine are two stimulants whose structures are shown in Table 21 of the Data Booklet.

(a) Describe **two** similarities in their structures, not including the presence of double bonds, methyl groups and nitrogen atoms. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Discuss the problems associated with nicotine consumption, distinguishing between short-term and long-term effects. *[6]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Blank page

Option C – Human biochemistry

C1. The structures of the amino acids cysteine and serine are shown in Table 20 of the Data Booklet. They can react with each other to form a dipeptide.

(a) State the type of reaction occurring when amino acids react together and identify the other product of the reaction. *[2]*

. . . . . .

. . . . . .

(b) Draw the structures of the **two** possible dipeptides formed in the reaction between one molecule of each of cysteine and serine. *[2]*

(c) Six tripeptides can be formed by reacting together one molecule of each of the amino acids arginine, histidine and leucine. Predict the primary structures of these six tripeptides using the symbols shown in Table 20 of the Data Booklet to represent the amino acids. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question C1 continued)

(d) When many amino acid molecules react together a protein is formed. These proteins have primary, secondary and tertiary structures.

(i) State the type of intermolecular force responsible for maintaining the secondary structure. *[1]*

. . . . . .

(ii) State **two** other ways in which the tertiary structure of the protein is maintained. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

C2. (a) State the empirical formula of all monosaccharides. *[1]*

. . . . . .

(b) The structural formula of lactose is shown in Table 22 of the Data Booklet.

(i) Deduce the structural formula of **one** of the monosaccharides that reacts to form lactose and state its name. *[2]*

(ii) State the name of the **other** monosaccharide. *[1]*

. . . . . .

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

. . . . . .

. . . . . .

. . . . . .

C3. The structural formulas of cholesterol and testosterone are shown in Table 22 of the Data Booklet.

(a) Identify the class of compound to which cholesterol and testosterone belong. *[1]*

. . . . . .

(b) State the names of **two** functional groups present in both cholesterol and testosterone. *[2]*

. . . . . .

. . . . . .

(c) Cholesterol and testosterone both contain a five-membered ring as part of their structures. Deduce the total number of hydrogen atoms joined directly to the carbon atoms in this ring. *[1]*

. . . . . .

. . . . . .

Option D – Environmental chemistry

D1. Particulates are a type of primary air pollutant produced in several industries and by the burning of fuels.

(a) The emission of particulates by some industries is reduced by an electrostatic method. Explain how this is done. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) State **one** type of fuel that is very likely to produce particulates when burned. *[1]*

. . . . . .

(c) Deduce the equation for a combustion reaction of methane in which particulates are formed. *[1]*

. . . . . .

. . . . . .

D2. (a) Explain, with the help of an equation, why rain is naturally acidic. *[2]*

. . . . . .

. . . . . .

(b) Catalytic converters are used in motor vehicles to reduce the emissions of acidic gases.

(i) Give an equation to show the formation of nitrogen(II) oxide in a motor vehicle and identify the acid it forms in the atmosphere. *[2]*

. . . . . .

. . . . . .

(ii) Nitrogen(II) oxide reacts with carbon monoxide in a catalytic converter to produce harmless substances. Deduce the equation for this reaction. *[2]*

. . . . . .

. . . . . .

D3. (a) State what is meant by the term *biological oxygen demand (BOD)*. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Organic matter in water can be decomposed by both aerobic and anaerobic bacteria.

(i) State which type of bacteria is more likely to be active in water with a low BOD value. *[1]*

. . . . . .

(ii) The following elements can occur in organic matter. Suggest **one** gas that is likely to be produced from each element when organic matter is decomposed by anaerobic bacteria. *[3]*

carbon . . . . . .

nitrogen . . . . . .

sulfur . . . . . .

(c) Power stations may use river water for cooling purposes. Discuss the effects of this on fish in such a river. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Option E – Chemical industries

E1. The extraction of metals from their ores often begins by using water to separate the ores from other materials found in the rock.

(a) State what is done to the rock before water is used. *[1]*

. . . . . .

. . . . . .

(b) An old method of extracting gold from its ore is *panning*, in which the gold and other impurities are mixed vigorously with water in a large dish. Suggest **one** physical property of gold that is important in its separation from impurities. *[1]*

. . . . . .

. . . . . .

(c) A more modern method of extracting ores from rock uses *froth flotation*. Outline this method by referring to the substances used, apart from the ore and water, and stating how the ore is separated from the rock. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(d) Explain why the percentage of gold in the Earth's crust occurring as the element is much higher than that of iron. *[1]*

. . . . . .

. . . . . .

E2. Aluminium and iron are extracted from their ores by different chemical methods. For aluminium, electrolysis is used.

(a) (i) Identify the compound from which most aluminium is extracted. *[1]*

. . . . . .

(ii) Electrolysis of this compound gives aluminium and another product. Write a half-equation for the formation of each product. *[3]*

. . . . . .

. . . . . .

(b) Most iron is produced by heating iron ore with coke in a blast furnace.

(i) State **two** other raw materials used in the blast furnace. *[1]*

. . . . . .

. . . . . .

(ii) Give the equation for the reduction of iron(III) oxide in the blast furnace. *[2]*

. . . . . .

. . . . . .

E3. The most widely-used polymer is polythene, which is made in low-density and high-density forms.

(a) Discuss the differences between these **two** forms by referring to the amount of branching, the forces between the polymer chains and the physical properties. *[4]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Both forms of polythene are described as *thermoplastics*.

(i) State the meaning of this term. *[1]*

. . . . . .

. . . . . .

(ii) Phenol-methanal is not a thermoplastic. State what type of polymer it is and how its structure differs from that of polythene. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Option F – Fuels and energy

F1. Crude oil contains many hydrocarbons, including hexane, C_6H_{14}.

(a) Outline how crude oil was formed. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) The equation for the complete combustion of hexane is shown below.

$$C_6H_{14}(g) + 9½O_2(g) \rightarrow 6CO_2(g) + 7H_2O\,(g)$$

Determine a value for the enthalpy of combustion of hexane using the following enthalpy of formation data. *[3]*

Compound	$C_6H_{14}(g)$	$CO_2(g)$	$H_2O\,(g)$
$\Delta H_f^{\ominus}$ / kJ mol^{-1}	–167	–394	–242

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question F1 continued)

(c) A student burned some hexane in a calorimeter and used the data obtained to calculate a value for the enthalpy of combustion of hexane. Explain why this value was a lot smaller than the one obtained using the method in part (b). *[1]*

. . . . . .

. . . . . .

(d) Hexane is not suitable for use as a fuel in car engines because of its low octane number. Suggest why its isomer, 2,3-dimethylbutane, has a higher octane number. *[1]*

. . . . . .

. . . . . .

F2. (a) Outline **two** features of chemical reactions that do **not** apply to nuclear reactions. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) The isotope ^{218}Po can undergo either α-decay or β-decay. Deduce the symbol and mass number of the element formed in each case. *[2]*

α-decay . . . . . .

β-decay . . . . . .

(c) The half-life for the decay of ^{218}Po is 3.0 minutes. Calculate the mass of ^{218}Po remaining after a 12 g sample is left for 12 minutes. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question F2 continued)

(d) Discuss the concerns about safety in nuclear power plants by commenting on **two** aspects of **each** of the following.

- the withdrawal of all the control rods from the core
- the presence of oxygen in the coolant gas passing through the graphite moderator
- the breakage of a pipe carrying molten sodium in a breeder reactor. *[6]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .