IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
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N05/4/CHEMI/SP3/ENG/TZ0/XX+

88056106

CHEMISTRY
STANDARD LEVEL
PAPER 3

Tuesday 8 November 2005 (morning)

1 hour

Candidate session number

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INSTRUCTIONS TO CANDIDATES

- Write your session 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 on answer sheets. Write your session 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 oxidation of nitrogen monoxide takes place as follows:

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

The following experimental data was obtained at 101.3 kPa and 298 K.

Experiment	Initial [NO] / mol dm^{-3}	Initial [O_2] / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
1	3.50×10^{-2}	1.75×10^{-2}	3.75×10^{-3}
2	3.50×10^{-2}	3.50×10^{-2}	7.50×10^{-3}
3	7.00×10^{-2}	7.00×10^{-2}	6.00×10^{-2}

(a) Deduce the order of reaction with respect to O_2. *[1]*

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

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

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(d) Calculate the value of the rate constant and state the units. *[2]*

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(e) Suggest a possible mechanism that is consistent with the rate expression. Indicate which of the steps is the rate-determining step. *[3]*

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A2. The hydrolysis of 2-iodo-2-methylpropane by $0.10\ \text{mol dm}^{-3}$ KOH(aq) to form 2-methylpropan-2-ol is an example of nucleophilic substitution.

(a) Give equations to illustrate the S_N1 mechanism for this reaction. *[2]*

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(b) Identify the rate-determining step and state a reason for your choice. *[1]*

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(c) State and explain whether the rate of each of the following reactions is greater than, less than or equal to the rate of the above reaction.

(i) 2-Chloro-2-methylpropane is reacted with $0.10\ \text{mol dm}^{-3}$ KOH(aq) at the same temperature. *[1]*

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(ii) 2-Iodo-2-methylpropane is reacted with $0.20\ \text{mol dm}^{-3}$ KOH(aq) at the same temperature. *[1]*

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A3. (a) The dissociation of water takes place as follows:

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$$

(i) State the expression for the ionic product constant of water, K_w. *[1]*

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(ii) The value of K_w is 2.4×10^{-14} mol^2 dm^{-6} at 310 K. Calculate the $[H^+]$ at 310 K. *[1]*

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(b) Lactic acid $CH_3CH(OH)COOH$ is a weak monoprotic acid ($pK_a = 3.85$ and $K_a = 1.4 \times 10^{-4}$ mol dm^{-3}).

(i) Write an equation for the reaction of lactic acid with water. *[1]*

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(ii) State the ionization constant expression, K_a for lactic acid. *[1]*

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(iii) Calculate the pH of a 0.20 mol dm^{-3} solution of lactic acid. *[2]*

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(iv) Determine the pH of a solution containing 0.10 mol dm^{-3} of lactic acid and 0.10 mol dm^{-3} of sodium lactate. *[1]*

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Option B – Medicines and drugs

B1. Magnesium hydroxide and aluminium hydroxide can act as antacids.

(a) Write an equation for the reaction of hydrochloric acid with one of the above antacids. *[2]*

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(b) Identify which antacid neutralizes the greater amount of hydrochloric acid if 0.1 mol of each antacid is used to neutralize the hydrochloric acid present in the stomach. *[1]*

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(c) Explain why sodium hydroxide is not used instead of these antacids. *[2]*

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B2. Acidified potassium dichromate(VI) is commonly used in roadside tests for ethanol in the breath of persons operating motor vehicles. It reacts with the ethanol present to form ethanoic acid.

(a) State the function of potassium dichromate(VI) and give the colour change that takes place in this reaction. *[2]*

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(b) Identify **two** other methods for the detection of ethanol in a persons breath or blood that are considered to be more accurate. *[2]*

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(c) State **one** harmful effect of aspirin that is more likely to occur if it is taken with ethanol. *[1]*

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(d) Diazepam and nitrazepam are two depressants that are very similar in their structures. State the name of **two** different functional groups present in both depressants. *[2]*

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B3. (a) Aspirin and acetaminophen (paracetamol) are classified as mild analgesics.

(i) State **one** advantage of aspirin, other than reducing pain, which is common to acetaminophen (paracetamol). *[1]*

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(ii) State **one** advantage of aspirin which is **not** common to acetaminophen (paracetamol). *[1]*

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(b) Morphine, codeine and heroin are classified as strong analgesics.

(i) Name **two** functional groups common to morphine, codeine and heroin. *[2]*

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(ii) A hospital patient has been prescribed morphine after surgery. State the main effect and a major side effect of this drug. *[2]*

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(c) For two comparable populations, the LD_{50} values (expressed as mg per kg body mass) for morphine and heroin is 20 and 4 respectively.

(i) Explain what is meant by the term LD_{50}. *[1]*

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(ii) Identify which of the **two** substances is more toxic with respect to these populations. *[1]*

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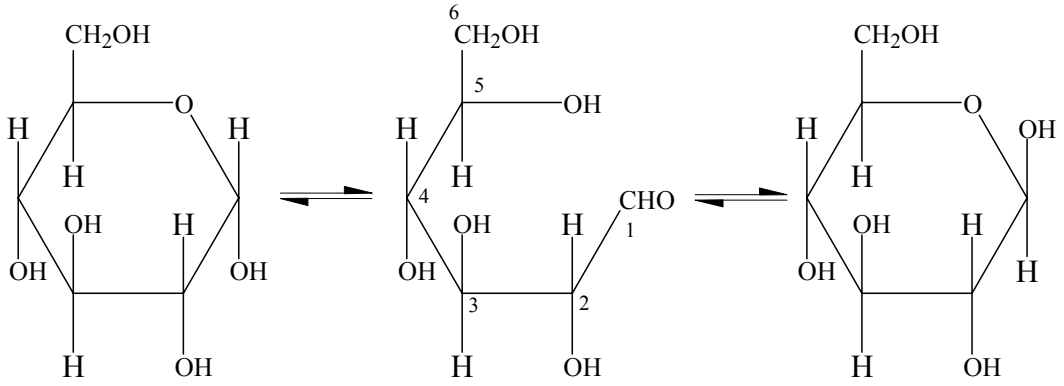
Option C – Human biochemistry

C1. (a) The equilibria which exists in an aqueous solution of glucose is shown in the structures below.



A B C

(i) Identify the α and β forms of glucose *[2]*

α glucose . . . . . .

β glucose . . . . . .

(ii) State, with a reason, whether or not the two ring forms of glucose are enantiomers. *[1]*

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(iii) In structure B identify, by stating the numbers, the carbon atoms which are **not** chiral. *[1]*

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(b) The structure of lactose, a disaccharide formed from glucose and galactose, is shown in the Data Booklet. Draw the ring structure of galactose and state whether it is an α or β isomer. *[2]*

(c) State **one** major function of polysaccharides such as starch and glycogen. *[1]*

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C2. (a) The general formula for saturated fatty acids is $C_nH_{2n}O_2$. The molecular formula of linoleic acid is $C_{18}H_{32}O_2$.

(i) Determine the number of carbon to carbon double bonds in linoleic acid. *[1]*

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(ii) Iodine number is defined as the number of grams of iodine that adds to 100 g of a fat or an oil in an addition reaction. Determine the iodine number of linoleic acid. *[2]*

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(b) (i) State **one** structural similarity between fats and oils. *[1]*

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(ii) Explain, by referring to their structures, why fats are solid at room temperature, but oils are liquid. *[3]*

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(This question continues on the following page)

(Question C2 continued)

(c) When a fat is reacted with aqueous sodium hydroxide, soap and one other product are formed.

(i) State the condition required for this reaction. *[1]*

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(ii) Draw the structural formula of the other product. *[1]*

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C3. (a) State the name of a disease which results from the deficiency of each of the following vitamins. *[2]*

vitamin A . . . . . .

vitamin C . . . . . .

vitamin D . . . . . .

(b) A person consumes an excess of both vitamin A and C. State, with a reason, which **one** is more likely to be stored in the body and which is more likely to be excreted. *[2]*

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Option D – Environmental chemistry

D1. (a) (i) Identify **three** primary pollutants produced by the automobile engine and describe how each one is produced. *[4]*

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(ii) Write an equation for the reaction that takes place between two primary pollutants in a catalytic converter. *[2]*

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(iii) State **one** natural and **one** man made source of sulfur dioxide in the atmosphere. *[2]*

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(b) Chlorofluorocarbons (CFCs) are one pollutant responsible for the depletion of the ozone layer. State **three** characteristic properties required for hydrofluorocarbons (HFCs) to be considered as alternatives to CFCs. *[3]*

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D2. (a) List **three** different methods by which sea water can be converted into fresh water. Discuss the essential features of one of the methods. *[6]*

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(b) State **one** similarity and **two** differences between drinking water treatment with chlorine and ozone. *[3]*

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Option E – Chemical industries

E1. Aluminium is extracted by the electrolysis of pure alumina in molten cryolite using graphite electrodes.

(a) Explain why aluminium is extracted by electrolytic reduction rather than carbon reduction. *[1]*

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(b) Explain why alumina has such a high melting point. *[1]*

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(c) Explain why molten cryolite is used in the extraction of aluminium. *[1]*

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(d) Write an ionic equation for the reaction that takes place at each electrode. *[2]*

positive electrode (anode) . . . . . .

negative electrode (cathode) . . . . . .

(e) Explain why the positive electrodes are replaced at regular intervals. *[1]*

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E2. (a) Apart from providing heat, state **one** other function of using coke in the blast furnace for the production of iron. *[1]*

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(b) Limestone is also added to the blast furnace. It decomposes to form calcium oxide and carbon dioxide. Identify the impurity removed by calcium oxide and explain why it reacts with this impurity. *[2]*

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(c) The basic oxygen converter is used to convert iron into steel. Molten impure iron from the blast furnace, scrap iron and two other substances are added to the converter.

(i) Name the **two** other substances added. *[2]*

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(ii) Explain the function of these **two** substances. *[2]*

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(d) Explain why aluminium resists corrosion. *[1]*

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E3. (a) Hexane can be converted to different products by three types of reforming processes. State the name and formula of the organic product formed in each case. *[3]*

aromatization . . . . . .

cyclization . . . . . .

isomerization . . . . . .

(b) Outline **two** reasons why sulfur compounds present in crude oil are removed. *[2]*

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(c) Identify the by-product of both cracking and reforming processes. *[1]*

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Option F – Fuels and energy

F1. The enthalpy of combustion values for three fossil fuels are as follows. (For coal and natural gas the major components are carbon and methane respectively. For petroleum, octane is one of the many components present).

		$\Delta H_c^{\ominus}$ / kJ mol^{-1}
coal	$C + O_2 \rightarrow CO_2$	–394
natural gas	$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$	–890
petroleum	$C_8H_{18} + 12\frac{1}{2}O_2 \rightarrow 8CO_2 + 9H_2O$	–5512

(a) If 1.00 g of coal on complete combustion produces 32.8 kJ of energy, determine the amount of energy produced when 1.00 g of each of the other two fossil fuels undergoes complete combustion. *[2]*

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(b) Compare the combustion of these fossil fuels as a source of air pollution by explaining the following.

(i) Coal produces the most sulfur dioxide. *[1]*

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(ii) Petrol (Gasoline) produces the most oxides of nitrogen. *[1]*

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(iii) All three fossil fuels produce carbon monoxide. *[1]*

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(This question continues on the following page)

(Question F1 continued)

(c) Write an equation for the formation of carbon monoxide by the combustion of natural gas. *[1]*

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(d) Calculate the volume of air needed for the complete combustion of 100 dm^3 of pure methane. (Assume that air contains 20 % oxygen by volume.) *[2]*

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(e) State **two** properties of components present in gasoline (petrol) which make them suitable for use in internal combustion engines. *[2]*

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(f) Octane rating is a measure of the ability of a fuel to resist "knocking" when burned in a standard test engine. Draw the structural formula of the compound with octane number 0 and the compound with octane number 100. *[2]*

octane number 0

octane number 100

(g) Identify the fraction present in crude oil which is used as jet fuel. *[1]*

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F2. The following reaction takes place in a lead-acid storage battery.

$$2PbSO_4(s) + 2H_2O(l) \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftharpoons}} Pb(s) + PbO_2(s) + 2H_2SO_4(aq)$$

(a) State the half-equations taking place at the negative electrode (anode) and the positive electrode (cathode) during the discharge of this battery. *[2]*

negative electrode (anode) . . . . . .

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positive electrode (cathode) . . . . . .

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(b) Identify the oxidizing and reducing agents in the above process. *[2]*

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(c) State **one** change in the electrolyte during the discharge process. *[1]*

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(d) State **one** advantage and **one** disadvantage of a lead-acid storage battery compared to a zinc-carbon battery. *[2]*

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