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

N03/420/S(3)

CHEMISTRY
STANDARD LEVEL
PAPER 3

Candidate number

Monday 10 November 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 reaction between 2-bromo-2-methylpropane, $(CH_3)_3CBr$, and warm aqueous $0.100\ mol\ dm^{-3}$ sodium hydroxide solution to form 2-methylpropan-2-ol, is found to have the following rate expression.

$$\text{rate} = k[(CH_3)_3CBr]$$

(a) (i) State what is meant by the term *rate of reaction*. *[1]*

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(ii) State the units for the rate constant, *k*. *[1]*

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(iii) Deduce what the effect on the rate of the reaction will be if the concentration of the sodium hydroxide solution is increased to $0.300\ mol\ dm^{-3}$. *[1]*

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(iv) Deduce the overall order of the reaction. *[1]*

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(v) It is found that after 32.0 seconds the concentration of 2-bromo-2-methylpropane falls to $\frac{1}{16}$ of its initial value. Calculate the half-life for the reaction. *[1]*

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(This question continues on the following page)

(Question A1 continued)

(b) (i) Name and describe the mechanism for the reaction between sodium hydroxide solution and 2-bromo-2-methylpropane. Use "curly arrows" to represent the movement of pairs of electrons. *[4]*

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(ii) Predict, giving a reason, how the rate of reaction will be affected if 2-iodo-2-methylpropane is used in place of 2-bromo-2-methylpropane. *[2]*

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(c) To confirm that the reaction between 2-bromo-2-methylpropane and sodium hydroxide solution had worked, a student isolated and purified the product. Describe the ^{1}H NMR spectrum of 2-methylpropan-2-ol using TMS (tetramethylsilane) as the reference. *[3]*

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A2. Explain the following observations.

(a) When benzene reacts with bromine in the presence of a catalyst the products are bromobenzene and hydrogen bromide. No addition reaction occurs. *[2]*

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(b) The mass spectrum of propan-1-ol shows a peak with a mass to charge ratio of 60 and also a peak at 31. *[2]*

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(c) There are two isomers of C_2H_6O. Only one shows a broad infrared absorption at about $3300\ cm^{-1}$. *[2]*

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Option B – Medicines and Drugs

B1. (a) List the **three** different ways in which drugs can be **injected** into the body. Predict, giving a reason, which of the three methods will result in the drug having the most rapid effect. *[4]*

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(b) State what is meant by *tolerance* towards a drug and explain why it is potentially dangerous. *[2]*

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B2. (a) One method for detecting alcohol in breath involves blowing through a tube containing crystals of acidified potassium dichromate(VI). The alcohol turns the crystals from orange to green. Explain what happens to both the dichromate(VI) ion and the alcohol in this reaction. *[2]*

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(b) A modern method for accurately determining the amount of alcohol in breath uses an intoximeter. Explain how an intoximeter works. *[3]*

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(c) Suggest why it is advisable not to drink alcohol when taking other drugs. *[2]*

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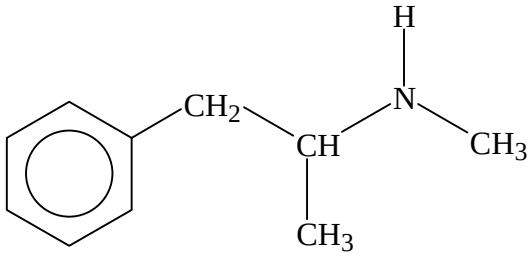
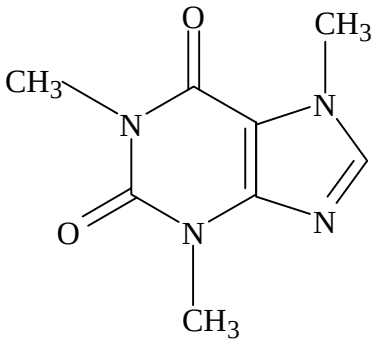
B3. Methylamphetamine (also known as methamphetamine or “speed”) and caffeine are stimulants with the following structures.



Methylamphetamine



Caffeine

(a) (i) On the structure for methylamphetamine above, draw a ring around the amine group. *[1]*

(ii) Determine whether both amine groups in caffeine are primary, secondary or tertiary. *[1]*

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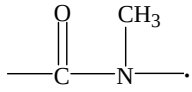
(b) Caffeine contains the group 

. State the general name for this functional group. *[1]*

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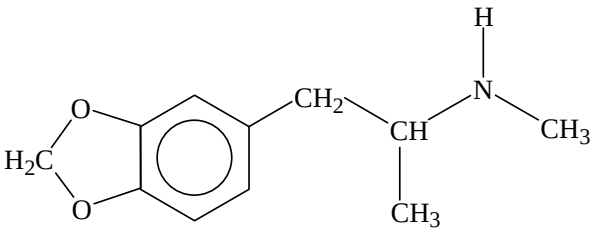
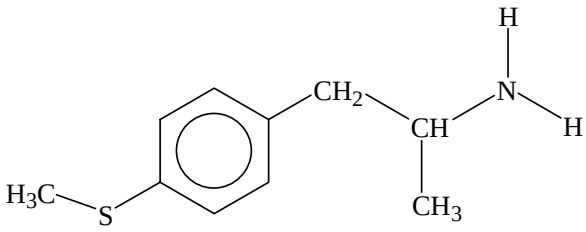
(Question B3 continued)

(c) A "designer drug" with a structure related to methylamphetamine is Ecstasy. Ecstasy tablets are sometimes contaminated with a substance called 4-MTA.



Ecstasy



4-MTA

(i) Methylamphetamine, Ecstasy and 4-MTA are sympathomimetic drugs. Identify the structural similarity between the three drugs and adrenaline, the structure of which is given in the Data Booklet. *[1]*

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(ii) Outline what is meant by the term *sympathomimetic drug* and state **one** example of a short-term effect sympathomimetic drugs have on the human body. *[2]*

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(iii) State **one** example of a long-term effect of taking stimulants. *[1]*

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Option C – Human biochemistry

C1. (a) State how genetically modified food differs from unmodified food. *[1]*

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(b) List **two** benefits and **two** concerns of using genetically modified crops. *[4]*

Benefits: . . . . . .

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Concerns: . . . . . .

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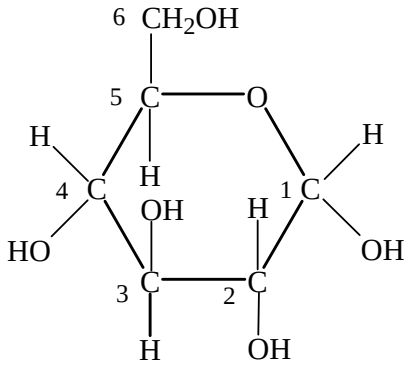
C2. (a) Draw the straight chain structure of glucose. *[1]*

(b) The structure of α-glucose is shown below.



Outline the structural difference between α-glucose and β-glucose. *[1]*

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(c) Glucose molecules can condense to form starch which can exist in two forms, amylose and amylopectin. Describe the structural differences between the two forms. *[2]*

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(This question continues on the following page)

(Question C2 continued)

(d) 1.00 g of sucrose, $C_{12}H_{22}O_{11}$, was completely combusted in a food calorimeter. The heat evolved was equivalent to increasing the temperature of 631 g of water from 18.36˚C to 24.58˚C. Calculate the calorific value of sucrose (in kJ mol^{-1}) given the specific heat capacity of water in Table 2 of the Data Booklet. *[3]*

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C3. Linoleic acid, $C_{17}H_{31}COOH$, ($M_r = 280$) and stearic acid, $C_{17}H_{35}COOH$, ($M_r = 284$) both contain eighteen carbon atoms and have similar molar masses.

(a) Explain why the melting point of linoleic acid is considerably lower than the melting point of stearic acid. *[3]*

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(b) Determine the maximum mass of iodine, I_2, ($M_r = 254$) that can add to

(i) 100 g of stearic acid: . . . . . *[1]*

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(ii) 100 g of linoleic acid: . . . . . *[2]*

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(c) (i) Draw the simplified structural formula of a fat containing one stearic acid and two linoleic acid residues. *[1]*

(ii) Give the formulas of the products formed when this fat is hydrolyzed by sodium hydroxide. *[1]*

Option D – Environmental chemistry

D1. For each of the primary pollutants below, state **one** chemical method used to reduce the amount entering the atmosphere and give **one** relevant equation relating to the chemistry behind the method.

(a) Carbon monoxide, CO: . . . . . *[2]*

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(b) Nitrogen(II) oxide, NO: . . . . . *[2]*

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(c) Sulfur(IV) oxide, SO_2: . . . . . *[2]*

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(d) Gasoline (petrol), C_8H_{18}: . . . . . *[2]*

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D2. CFCs lower the concentration of ozone in the ozone layer. Following the 1987 Montreal Protocol, the use of CFCs is being phased out. Two alternatives to CFCs are HCFCs (*e.g.* chlorodifluoromethane, CHF_2Cl) and hydrocarbons (*e.g.* 2-methylpropane, C_4H_{10}).

(a) Apart from being less harmful to the ozone layer, state **two** other properties that alternatives to CFCs must possess. *[2]*

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(b) Discuss the relative advantages and disadvantages of using chlorodifluoromethane and 2-methylpropane as alternatives to CFCs. *[3]*

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D3. (a) Explain using an equation why rain falling in unpolluted air is acidic with a pH of about 5.7. *[2]*

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(b) "Acid rain" has a pH less than 5.6. Explain using an equation how the burning of coal can contribute to acid rain formation. *[2]*

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(c) "Acid rain" can affect plants and buildings.

(i) Outline how acidic soil can damage the growth of trees. *[1]*

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(ii) Give an equation for the reaction of acid rain on marble statues or limestone buildings. *[1]*

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(d) Explain how the addition of calcium oxide to lakes could neutralize the effects of "acid rain". *[1]*

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Option E – Chemical industries

E1. Discuss the **two** main factors that influence the chemical methods used to extract different metals from their ores. Use sodium, lead and silver as examples to illustrate your answer. *[5]*

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E2. (a) (i) Apart from the availability of raw materials, energy and a good transport system, list **three** factors that influence the location of modern chemical industries producing consumer products. *[3]*

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(ii) State the difference between intermediate products and consumer products in the chemical industry and give **one** example of each. *[2]*

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(b) State **one** example of the use of biotechnology in chemical manufacture. *[1]*

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E3. (a) Traditionally, the raw materials for the production of iron are iron ore, coke, limestone and preheated air. Iron oxides are reduced in a blast furnace by both carbon and carbon monoxide to form iron. Give the equation for the reduction of iron(III) oxide by carbon monoxide. *[1]*

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(b) In many modern blast furnaces, hydrocarbons, (such as methane) are also added to the preheated air. This produces carbon monoxide and hydrogen. The hydrogen formed can also act as a reducing agent. Give the equation for the reduction of magnetite, Fe_3O_4, by hydrogen. *[1]*

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(c) The iron produced in the blast furnace is known as "pig iron". It contains about 5 % carbon, together with small amounts of other elements such as phosphorus and silicon.

Explain the chemical principles behind the conversion of iron into steel using the basic oxygen converter. *[6]*

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(d) State **one** element that must be added to the basic oxygen converter to produce stainless steel rather than ordinary steel. *[1]*

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Option F – Fuels and energy

F1. (a) State **two** essential differences between chemical bond breaking and nuclear fission. *[2]*

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(b) (i) Deduce the identity of the product X in the following nuclear reaction. *[1]*

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

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(ii) Explain the origin of the energy released in the above reaction in terms of the masses of the reactants and products. *[1]*

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(c) The half-life of $^{238}_{92}\mathrm{U}$ is 4.50×10^{9} years. Deduce the time taken for 1000 tonnes of $^{238}_{92}\mathrm{U}$ to decay to 125 tonnes of the same isotope. *[1]*

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(d) A nuclear reactor contains control rods and moderators.

(i) Explain the function of *[2]*

control rods: . . . . . .

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moderators: . . . . . .

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(ii) State **one** example of a material used in control rods. *[1]*

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(e) Both nuclear and conventional power stations use a turbine to drive a generator to produce electricity. Explain why nuclear power stations contain a secondary coolant whereas conventional power stations may only have a primary coolant. *[1]*

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F2. Automobiles in some countries are able to run on either gasoline (petrol) or on a mixture of gasoline and ethanol known as "gasohol".

(a) Explain what is meant when gasoline is said to have an octane rating of 98. *[1]*

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(b) Give the equation for the complete combustion of octane. *[1]*

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

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(d) The enthalpies of combustion of pure octane and ethanol are given in the Data Booklet. Deduce the maximum amount of energy available from burning:

(i) 1.00 kg of octane $(M_r = 114.0)$. *[1]*

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(ii) 1.00 kg of gasohol which contains 20 % ethanol $(M_r = 46.0)$ and 80 % octane by mass. *[2]*

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F3. (a) State the name given to the process whereby solar energy can be converted **directly** into electricity. *[1]*

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(b) Describe how the above process can be achieved practically. *[2]*

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(c) List **two** advantages of this method of obtaining electricity. *[2]*

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