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

N06/4/CHEMI/HP3/ENG/TZ0/XX+

88066103

CHEMISTRY
HIGHER LEVEL
PAPER 3

Thursday 9 November 2006 (morning)

1 hour 15 minutes

Candidate session number

0	0							

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 and your cover sheet 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.

0130

Option B – Medicines and drugs

B1. Nicotine and caffeine are two common stimulants.

(a) Apart from the methyl groups, state the name of **one** functional group, which is present in **both** nicotine and caffeine. *[1]*

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(b) State the name of **one** functional group, which is present in caffeine, but absent in nicotine. *[1]*

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(c) Suggest, with a reason, whether an aqueous solution of nicotine would be acidic, basic or neutral. *[2]*

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(d) State **two** effects of consuming caffeine in large amounts. *[1]*

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(e) State **two** short-term physical effects of nicotine consumption. *[1]*

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(f) Explain the term *sympathomimetic* drug and state **one** example other than nicotine. *[2]*

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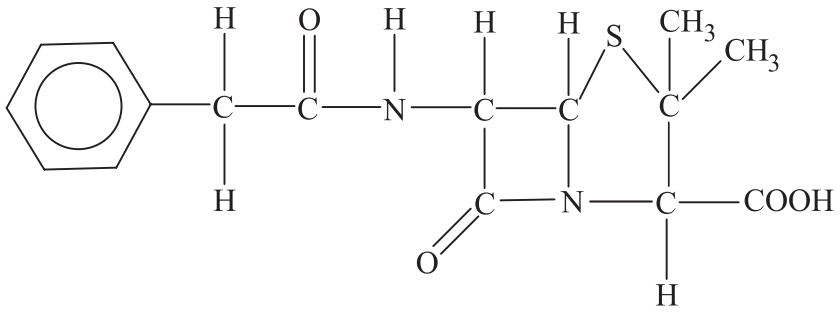
B2. Penicillin G was the first antibiotic used to fight infections. The structure of this antibiotic is as follows:



(a) Determine the molecular formula of penicillin G. *[1]*

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(b) State **two** reasons for modifying the side chain in penicillin G. *[2]*

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(c) Explain the difference between *broad-spectrum* and *narrow-spectrum* antibiotics. *[1]*

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(d) Describe the mode of action of penicillin in preventing the growth of bacteria. *[2]*

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(e) Discuss **two** effects of over prescription of penicillin to humans. *[2]*

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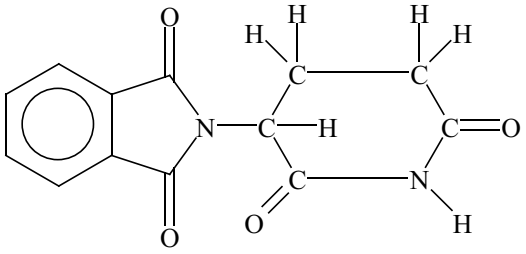
B3. (a) The structure of the drug thalidomide is as follows:



(i) Identify the chiral carbon atom in the structure of thalidomide using an asterisk (*). *[1]*

(ii) State the effect of each of the **two** isomers of thalidomide in human beings. *[2]*

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(b) The compound cisplatin is an example of an inorganic complex that has an isomer.

(i) Draw the structures of cisplatin and its isomer. *[1]*

(ii) State with a reason the type of isomerism shown by cisplatin in b(i). *[1]*

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(iii) Identify the isomer that has an important pharmacological effect and state the name of the disease it treats. *[1]*

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(This question continues on the following page)

(Question B3 continued)

(c) Indole is an example of an amine.

(i) State whether the amine group in indole is primary, secondary or tertiary. *[1]*

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(ii) Identify **two** mind-altering drugs that have the indole ring structure. *[1]*

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(d) Identify the active ingredient present in cannabis (marijuana). *[1]*

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Option C – Human biochemistry

C1. (a) The equilibria, which exist in an aqueous solution of glycine, are shown in the structures below.

$$\underset{\mathbf{A}}{H_2N—CH_2—COO^-} \rightleftharpoons \underset{\mathbf{B}}{H_3N^+—CH_2—COO^-} \rightleftharpoons \underset{\mathbf{C}}{H_3N^+—CH_2—COOH}$$

State which of the forms A, B or C occurs in the greatest concentration at:

low pH:. . . . . .

high pH: . . . . . *[2]*

(b) A mixture of amino acids with different isoelectric points can be separated using electrophoresis.

(i) Outline the essential features of electrophoresis. *[3]*

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(ii) Arginine, glutamic acid and glycine undergo electrophoresis at pH 6.0. Using table 20 of the Data Booklet identify the amino acid that moves towards: *[2]*

the positive electrode: . . . . . .

the negative electrode:. . . . . .

C2. Iodine number is defined as the number of grams of iodine that reacts with 100 g of a triglyceride in an addition reaction. The iodine number of palmitic acid ($M_r = 256$) is 0 and linolenic acid ($M_r = 278$) is 274.

Determine the number of double bonds in linolenic acid, showing your working. *[3]*

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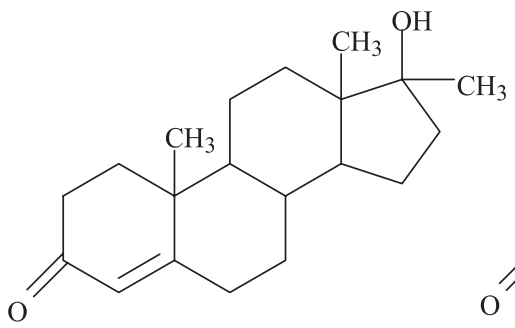
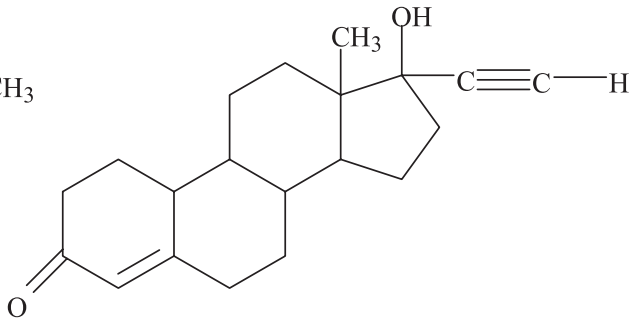
C3. The structures of two synthetic hormones are shown below:



A



B

Hormone **A** is similar in structure to testosterone and hormone **B** is similar in structure to progesterone.

(a) Explain why hormone **A** is prescribed to some patients. *[2]*

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(b) Suggest why hormone **A** is banned for participants in major sporting events. *[1]*

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(c) Describe how hormone **B** functions as an oral contraceptive. *[2]*

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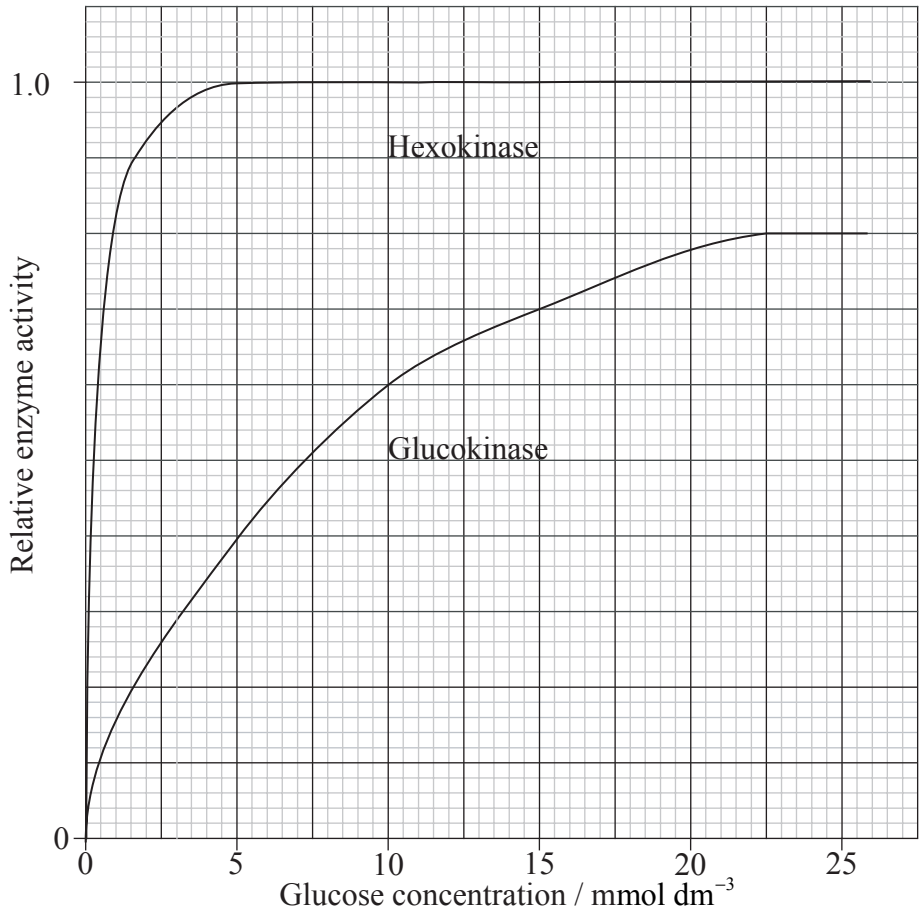
C4. (a) Two types of enzymes, hexokinase and glucokinase, catalyse the conversion of glucose to glucose-6-phosphate.



(i) Explain what is meant by the term K_m and state its relationship with the enzyme activity. *[2]*

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(ii) Calculate the value of K_m for glucokinase from the graph. *[1]*

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(This question continues on the following page)

(Question C4 continued)

(iii) State with a reason whether the value of K_m will increase, decrease, or remain the same for glucokinase when one of the following inhibitors is added: *[4]*

competitive inhibitor . . . . . .

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non-competitive inhibitor . . . . . .

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(b) Iron and copper ions are part of cytochromes and undergo oxidation and reduction in the electron transport process.

(i) Identify the molecule which undergoes oxidation, and the molecule which undergoes reduction in the above process. *[2]*

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(ii) Give a half-equation for the process of reduction. *[1]*

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Option D – Environmental chemistry

D1. (a) Explain the term *acid rain* in terms of pH. *[1]*

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(b) Identify **two** acids that cause acid rain and indicate the origin of each one. *[4]*

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(c) Write an equation to show how **one** of these acids is produced. *[1]*

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D2. Large-scale combustion of fossil fuels has been a major source of increased levels of CO_2 in the atmosphere.

(a) Describe a possible effect of higher levels of CO_2 in the atmosphere. *[1]*

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(b) Identify **one** natural method by which CO_2 is removed from the atmosphere and give an equation for the reaction. *[2]*

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D3. Waste water and sewage undergo primary, secondary and tertiary stages of treatment.

(a) State **two** features of the activated sludge process that allow for the removal of impurities. *[2]*

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(b) Identify **one** major source of phosphate in waste water. *[1]*

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(c) State the type of reaction used to remove Pb^{2+} and PO_4^{3-} ions from waste water. For each ion, give an equation to show its removal. *[3]*

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D4. (a) Identify **two** primary pollutants in photochemical smog and explain how **one** of these pollutants is produced. *[3]*

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(b) Identify **two** secondary pollutants in photochemical smog other than NO_2 and O_3. Explain with the help of an equation how **one** of these pollutants is produced. *[3]*

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(c) Mercury and nitrates cause serious health problems when present in polluted water. Identify a source of each of these pollutants and state a health problem caused by each pollutant. *[4]*

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Option E – Chemical industries

E1. (a) Crude oil may contain small amounts of H_2S. Write an equation to show how H_2S is removed from crude oil. *[1]*

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(b) Crude oil is a mixture of volatile substances. The process of fractional distillation separates crude oil into different fractions.

(i) Describe the process of fractional distillation. *[4]*

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(ii) Explain why smaller molecules present in crude oil have relatively low boiling points. *[1]*

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(c) One of the compounds obtained from fractional distillation is $C_{16}H_{34}$. Give an equation for the catalytic cracking of $C_{16}H_{34}$ to produce two molecules with the **same** number of carbon atoms. *[1]*

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E2. Polyethene is the most commonly used synthetic polymer. It is produced in low-density and high-density forms.

(a) Identify which form has the higher melting point. Explain by reference to its structure and bonding. *[4]*

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(b) Describe how the properties of **two** named polymers can be modified by adding a different substance in each case. *[4]*

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E3. (a) Compare the different processes used to manufacture low-density and high-density polyethene, by referring to reaction conditions, the name of the catalyst and the type of reaction mechanism. *[4]*

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(b) The basis of the chlor-alkali industry is the manufacture of chlorine and sodium hydroxide from brine.

(i) Write half-equations for the reaction taking place at each electrode in both the diaphragm cell and the mercury cell. *[3]*

positive electrode

diaphragm cell . . . . . .

mercury cell . . . . . .

negative electrode

diaphragm cell . . . . . .

mercury cell . . . . . .

(ii) Identify the material used for the diaphragm and describe its function. *[3]*

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Option F – Fuels and energy

F1. (a) ^{226}Ra emits one α particle and two β particles in a decay process.

Determine the atomic number and mass number of the final product formed by this decay process. *[2]*

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(b) The half-life of ^{90}Sr is 27 years. A sample of this nuclide has an initial activity of 8000 disintegrations per minute (dpm). Calculate the activity in dpm after 135 years. *[2]*

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F2. (a) Both nuclear fusion and nuclear fission produce large amounts of energy. Describe **one** disadvantage and **two** advantages of nuclear fusion as compared to nuclear fission. *[3]*

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(b) Both nuclear and conventional (fossil fuel) power plants generate electricity by producing heat that is used to convert water to steam.

State **two** advantages and **two** disadvantages of nuclear power plants as compared to conventional (fossil fuel) power plants. *[4]*

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F3. Biomass can be used to produce biogas and ethanol.

(a) Identify the major component of biogas and explain how it is produced. *[2]*

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(b) State **two** conditions required for the production of ethanol from biomass. *[2]*

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(c) Give a chemical equation for the production of ethanol from biomass. *[1]*

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F4. (a) Discuss the doping of silicon to produce different types of semiconductors. Describe how sunlight interacts with semiconductors. *[5]*

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(b) Describe the difference between low-level and high-level nuclear waste and give **one** example of each. *[2]*

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(c) The half life of ^{251}Cf is 800 years. Calculate the time for the activity of a sample of ^{251}Cf to decrease to 8 % of the original value. *[2]*

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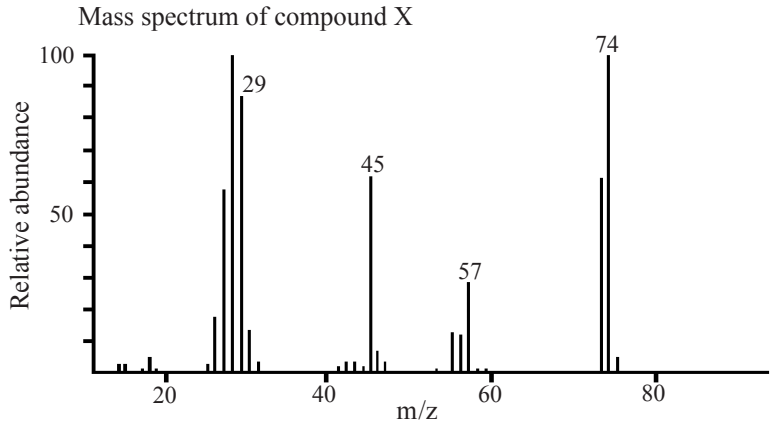
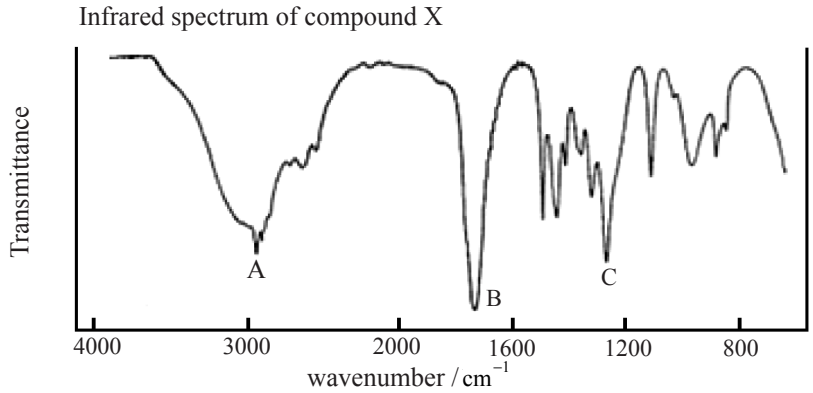
Option G – Modern analytical chemistry

G1. An organic compound X contains 48.6 % of carbon, 8.2 % of hydrogen and 43.2 % of oxygen by mass. The mass spectrum and infrared spectrum of this compound are as follows:





(a) Calculate the empirical formula of this compound. *[1]*

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(b) Deduce, stating a reason for your answer, the molecular formula of this compound. *[1]*

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(This question continues on the following page)

(Question G1 continued)

(c) Suggest the formula of the fragmentation ion that could be responsible for the peak at each of the following m/z values. *[3]*

57 . . . . . .

45 . . . . . .

29 . . . . . .

(d) Identify the bond responsible for each of the absorptions labelled A, B and C. *[2]*

A . . . . . .

B . . . . . .

C . . . . . .

(e) The compound X exists as **three** structural isomers. An ^{1}H NMR spectrum was obtained for each isomer. Draw the structural formula of the **three** isomers and deduce the splitting pattern in each case. *[6]*

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(This question continues on the following page)

(Question G1 continued)

(f) Suggest with a reason the identity of compound X. *[2]*

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G2. (a) Electronic transitions occur when a molecule absorbs energy from the visible or UV regions of the electromagnetic spectrum.

(i) Predict the region (visible or UV) in which benzene and nitrobenzene would absorb energy. *[2]*

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(ii) Explain why CH_2=CH–CH=CH_2 shows an absorption band at a longer wavelength than CH_2=CH_2. *[2]*

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(iii) Explain why compounds of Zn^{2+} and Cu^{+} are colourless. *[2]*

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(b) An aqueous solution of copper(II) sulfate is light blue, but when excess ammonia is added the colour changes to dark blue.

(i) State the formula of the copper(II) complex ions in each of the **two** solutions. *[2]*

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(ii) Explain why the colour of copper complex solutions is different when different ligands are present. *[2]*

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Option H – Further organic chemistry

H1. (a) There are **geometrical** isomers of the cyclic compound $C_4H_6Cl_2$. Draw the structural formula of two isomers and explain why these two isomers exist. *[3]*

cis-isomer trans-isomer

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(b) (i) Draw the structural formulas of **two** isomers of but-2-ene-1,4-dioic acid. *[2]*

(ii) State and explain which isomer will have a lower melting point. *[2]*

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(iii) Describe how the two isomers can be distinguished by a chemical test. *[2]*

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(This question continues on the following page)

(Question H1 continued)

(c) Consider the following compounds:
1-chloropentane, 2-chloropentane, 3-chloropentane

(i) Identify the compound which exhibits optical isomerism and draw the structures of the **two** isomers. *[3]*

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(ii) Describe how these **two** isomers can be distinguished experimentally. *[1]*

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H2. (a) Both pentan-2-one and pentan-3-one have a boiling point of 102 °C.

(i) Describe how the **two** compounds can be distinguished using an addition elimination reaction. *[2]*

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(ii) Draw the structure of the reagent and the organic product of the reaction in (a) (i) using pentan-2-one. *[2]*

(b) Pentan-2-one reacts with hydrogen cyanide. Describe the mechanism of the reaction, using curly arrows to represent the movement of electron pairs. *[4]*

H3. Discuss how the acidic strength of 2,2-dimethylpropanoic acid and trichloroethanoic acid compare with ethanoic acid. *[4]*

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