22096118

International Baccalaureate®
Baccalauréat International
Bachillerato Internacional

CHEMISTRY
STANDARD LEVEL
PAPER 3

Tuesday 19 May 2009 (morning)

1 hour

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.

0125

Option A — Modern analytical chemistry

A1. (a) Distinguish between an absorption spectrum and an emission spectrum. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Identify the most suitable spectroscopic technique to

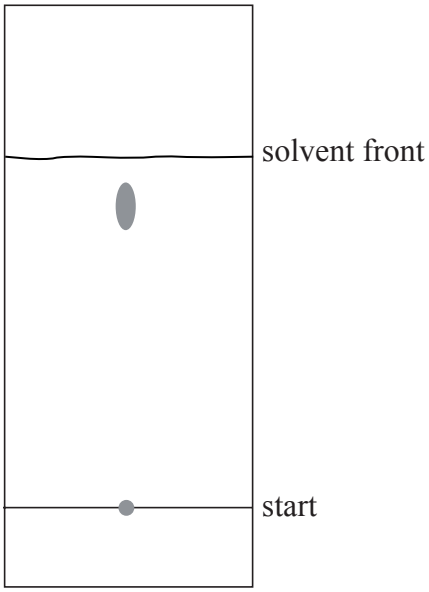
(i) distinguish between butan-1-ol and butan-2-ol. *[1]*

. . . . . .

(ii) determine the concentration of cadmium ions in polluted water. *[1]*

. . . . . .

(c) The following diagram represents a thin-layer chromatogram of an amino acid.



(i) Outline the principle of thin-layer chromatography. Refer in your answer to the nature of the mobile and stationary phases and the reason why a mixture of amino acids can be separated using this method. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question A1 continued)

(ii) State **one** advantage of thin-layer chromatography over paper chromatography. *[1]*

. . . . . .

. . . . . .

(iii) Calculate the R_f of the amino acid. *[1]*

. . . . . .

. . . . . .

A2. Mass spectrometry is a powerful analytical technique used in the identification of organic compounds. The mass spectrum of a compound with empirical formula CH_2O displays peaks at *m/z* 15, 45 and 60.

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

. . . . . .

. . . . . .

(b) Identify the fragments responsible for the peaks at *[2]*

m/z = 15 . . . . . .

m/z = 45 . . . . . .

(c) Identify a compound that could produce this spectrum. *[1]*

. . . . . .

. . . . . .

A3. Infrared spectroscopy is an analytical technique that uses electromagnetic radiation.

(a) Compare infrared radiation and visible light in terms of the processes that occur in atoms and molecules upon absorption. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Explain at the molecular level why oxygen molecules do not absorb infrared radiation. *[2]*

. . . . . .

. . . . . .

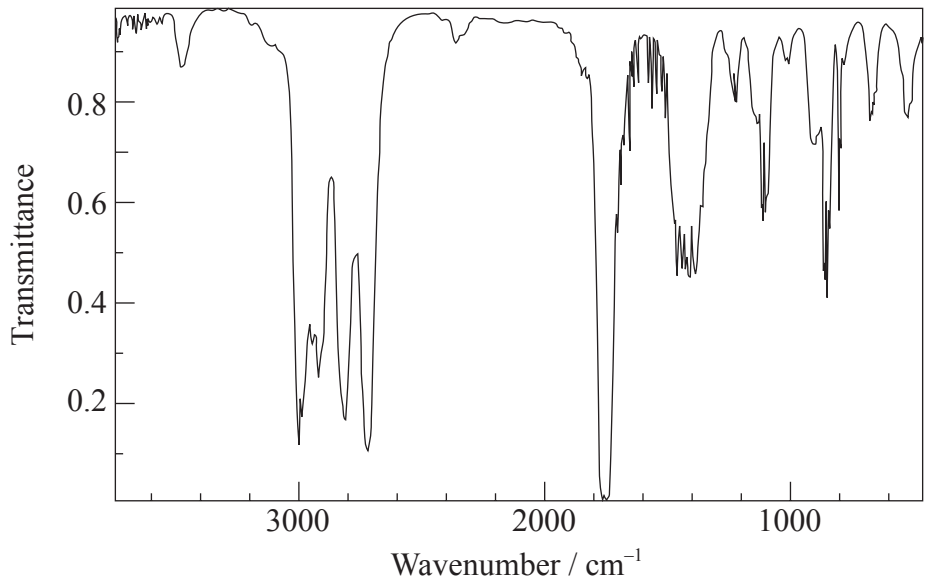
. . . . . .

. . . . . .

(This question continues on the following page)

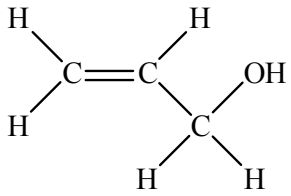
(Question A3 continued)

(c) The infrared spectrum of a substance, X, with empirical formula C_3H_6O is given below.



[Source: NIST http://webbook.nist.gov/chemistry]

(i) Explain why the structural formula of X **cannot** be: *[2]*



. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) The ^{1}H NMR spectrum of X consists of three peaks. Deduce the structural formula of X and the relative areas under each peak. *[2]*

. . . . . .

. . . . . .

Option B — Human biochemistry

B1. Glucose is a monomer of starch.

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

(b) Explain why **two** cyclic isomers are formed from the straight-chain glucose and name both isomers. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) State the name of the **two** polymeric forms of starch. *[1]*

. . . . . .

. . . . . .

(d) Compare the structure and linkage between the glucose monomers in both polymeric forms. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

B2. Cholesterol belongs to a class of substances named lipids.

(a) Identify the characteristic structural feature of cholesterol. *[1]*

. . . . . .

. . . . . .

(b) Identify **two** other types of lipids found in the human body. *[2]*

. . . . . .

. . . . . .

(c) (i) State what the terms *HDL* and *LDL* represent. *[1]*

. . . . . .

. . . . . .

(ii) Outline **one** chemical difference between HDL and LDL. *[1]*

. . . . . .

. . . . . .

(d) Compare the structures of linoleic acid and linolenic acid. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

B3. Vitamins are micronutrients essential for good health.

(a) Compare the solubilities of vitamins A and C in water by referring to the structures provided in Table 21 of the Data Booklet. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Describe the effect of deficiency of **one** of these vitamins and suggest **two** possible solutions. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Option C — Chemistry in industry and technology

C1. Alloys are important substances in industries that use metals.

(a) Describe an alloy. *[1]*

. . . . . .

. . . . . .

(b) Explain how alloying can modify the structure and properties of metals. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) Describe the effect of the *tempering* process on steel. *[1]*

. . . . . .

. . . . . .

(d) Discuss the environmental impact of iron and aluminium production. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

C2. Compare the modes of action of homogeneous and heterogeneous catalysts. State **one** example of each type of catalysis using a chemical equation **and** include state symbols. *[4]*

Mode of action of homogeneous catalysis:

. . . . . .

. . . . . .

Example using chemical equation:

. . . . . .

. . . . . .

Mode of action of heterogeneous catalysis:

. . . . . .

. . . . . .

Example using chemical equation:

. . . . . .

. . . . . .

C3. The high activity of lithium metal leads to the formation of an oxide layer on the metal which decreases the contact with the electrolyte in a battery.

(a) Describe how this is overcome in the lithium-ion battery. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question C3 continued)

(b) Describe the migration of ions taking place at the two electrodes in the lithium-ion battery when it produces electricity. *[2]*

Anode (–):

. . . . . .

. . . . . .

Cathode (+):

. . . . . .

. . . . . .

(c) Discuss **one** similarity and **one** difference between fuel cells and rechargeable batteries. *[2]*

Similarity:

. . . . . .

. . . . . .

Difference:

. . . . . .

. . . . . .

C4. (a) Compare the positional and directional order in a crystalline solid, nematic phase liquid crystal and a pure liquid. Show your answer by stating **yes** or **no** in the table below. *[2]*

	Crystalline solid	**Nematic phase liquid crystal**	**Pure liquid**
Positional order			
Directional order			

(b) Outline any **two** principles of a liquid-crystal display device. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Option D — Medicines and drugs

D1. Medicines and drugs can influence the functioning of the body.

Discuss the term *therapeutic window*. Your answer should include its meaning, a quantitative description and an explanation of **wide** and **narrow** therapeutic windows. *[4]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

D2. The walls of the human stomach contain cells that produce gastric juices. Sodium hydrogencarbonate is an antacid often used to neutralize excess acid.

(a) State an equation for the reaction of stomach acid with this antacid. *[1]*

. . . . . .

. . . . . .

(b) Calcium carbonate can also neutralize stomach acid. The same amounts (in moles) of sodium hydrogencarbonate and calcium carbonate are available. Deduce which antacid will neutralize the greater amount of acid present in the stomach and explain your reasoning. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

D3. Ethanol, a depressant, is sufficiently volatile to pass into the lungs from the bloodstream. The roadside breathalyser test uses acidified potassium dichromate(VI) which reacts with any ethanol present in the breath and converts it to ethanoic acid.

(a) (i) State the oxidation and reduction half-equations that occur in the breathalyser when ethanol is present in the breath. *[2]*

Oxidation:

. . . . . .

. . . . . .

Reduction:

. . . . . .

. . . . . .

(ii) Describe the colour change that occurs to the acidified dichromate(VI) if ethanol is present in the breath. *[1]*

. . . . . .

. . . . . .

(b) Police use the intoximeter, an infrared spectrophotometer to confirm a roadside breathalyser test. Explain how the amount of ethanol is determined from the infrared spectrum. *[2]*

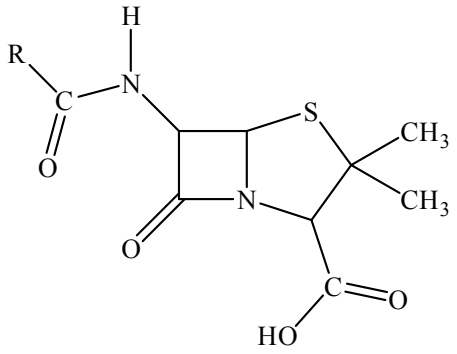
. . . . . .

. . . . . .

. . . . . .

. . . . . .

D4. Antibacterials are drugs that kill or inhibit the growth of microorganisms that cause infectious diseases. The general structure of penicillin, an antibacterial, is given below.



(a) With reference to the structure above, state what the letter R represents and discuss how penicillins can be made more resistant to the penicillinase enzyme. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Describe and explain **one** effect of overprescription of antibacterials. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

D5. Describe and explain difficulties associated with solving the AIDS problem. *[4]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Blank page

Option E — Environmental chemistry

E1. The exhaust gases of automobiles contribute significantly to air pollution in cities.

(a) Outline how the pollutant gases nitrogen(II) oxide, NO, nitrogen(IV) oxide, NO_2 and carbon monoxide, CO, are formed as a result of the action of the internal combustion engine. *[3]*

NO:

. . . . . .

. . . . . .

NO_2:

. . . . . .

. . . . . .

CO:

. . . . . .

. . . . . .

(b) One way to reduce automobile pollution is to control the fuel to air ratio. Discuss the impact of **increasing** the fuel/air ratio on the concentrations of volatile organic compounds (VOC's), CO and NO in exhaust gases. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

E2. Chlorofluorocarbons, CFCs, deplete the ozone layer.

(a) State the name of **one** source of CFCs. *[1]*

. . . . . .

. . . . . .

(b) In terms of their properties, suggest **two** reasons why CFCs continue to be used widely. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) State **one** advantage and **one** disadvantage of using tetrafluoromethane as an alternative to CFCs. *[2]*

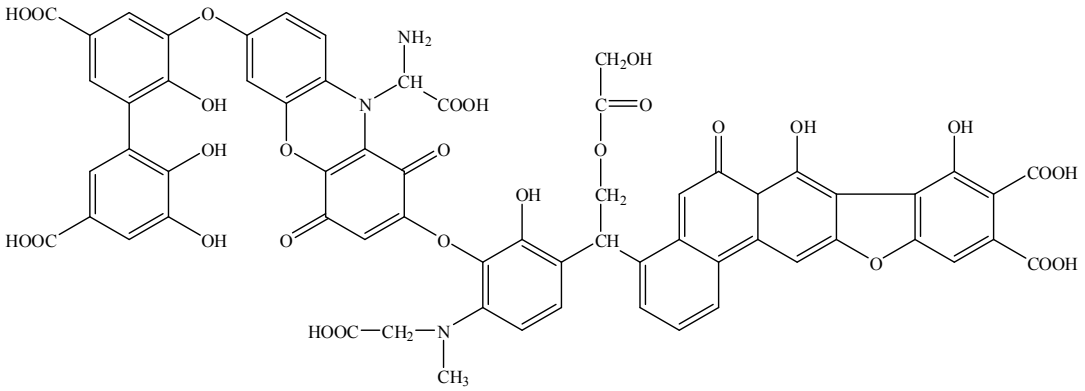
. . . . . .

. . . . . .

. . . . . .

. . . . . .

E3. (a) The following molecule is found in soil organic matter, SOM.



(i) State a main constituent of SOM. *[1]*

. . . . . .

. . . . . .

(ii) Explain, with reference to the structure above, how SOM can increase the soil quality, in terms of the following. *[3]*

Provision of nutrients:

. . . . . .

. . . . . .

Water retention:

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Discuss how irrigation can cause soil degradation. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question E3 continued)

(c) State the name of **one** source for each of the following organic soil pollutants. *[2]*

Polyaromatic hydrocarbons (PAHs):

. . . . . .

. . . . . .

Organotin compounds:

. . . . . .

. . . . . .

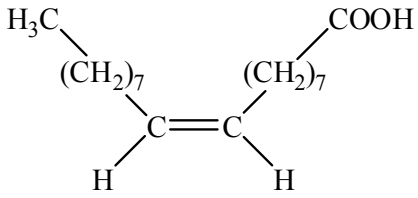
Option F — Food chemistry

F1. (a) Describe the chemical composition of a triglyceride. *[1]*

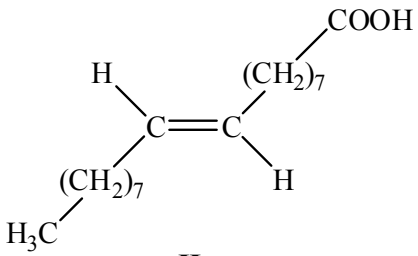
. . . . . .

. . . . . .

(b) The following two structures represent isomers of a fatty acid.



I



II

State and explain which isomer has the higher melting point. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) Discuss **two** advantages and **two** disadvantages of hydrogenating oils. *[4]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

F2. The label of a can of meat indicates that it has the following ingredients:

Meat, water, salt, spices, sodium ascorbate, sodium nitrite, sodium tripolyphosphate, flavourings and paprika extract.

(a) List the **two** main nutrients found in the can of meat. *[2]*

. . . . . .

. . . . . .

(b) Outline how canning increases the shelf life of the meat. *[2]*

. . . . . .

. . . . . .

. . . . . .

(c) State the function of

(i) sodium nitrite. *[1]*

. . . . . .

. . . . . .

(ii) sodium ascorbate. *[1]*

. . . . . .

. . . . . .

F3. (a) Explain why raw meat changes colour from purplish-red to brown on standing. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Explain why food pigments are coloured. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Option G — Further organic chemistry

G1. Benzene is an important molecule containing delocalized electrons.

(a) Explain the term *delocalized electrons*. *[1]*

. . . . . .

. . . . . .

(b) State and explain **one** piece of physical evidence and **one** piece of chemical evidence for the presence of delocalized electrons in the structure of benzene. *[4]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) Describe and explain the relative rates of the reactions of hydroxide ions with chlorobenzene, C_6H_5Cl, and (chloromethyl)benzene, $C_6H_5CH_2Cl$. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

G2. Predict and explain the structures of the **major** and **minor** products when hydrogen bromide is added to 2-methylbut-2-ene, $(CH_3)_2CCHCH_3$. *[5]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

G3. Draw the structural formulas of the **two** elimination products formed when butan-2-ol, $CH_3CH_2CH(OH)CH_3$ is heated with phosphoric acid. *[2]*

G4. (a) Outline the formation of a Grignard reagent. Include any necessary conditions. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) 2-methylbutan-2-ol is formed by the reaction of a ketone with a Grignard reagent. Draw the structural formula of 2-methylbutan-2-ol and deduce the structural formulas of the ketone and the Grignard reagent used for the reaction. *[3]*

. . . . . .

. . . . . .