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International Baccalaureate®
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CHEMISTRY
STANDARD LEVEL
PAPER 3

Friday 12 November 2010 (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 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. There is a wide range of analytical techniques available to chemists.

(a) State **two** reasons why the use of analytical chemistry techniques is important in society today. *[1]*

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(b) Identify which analytical technique is regularly used for

(i) separation of a mixture of sugars. *[1]*

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(ii) ^{14}C isotopic dating. *[1]*

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(iii) scanning of the human body to detect diseases such as cancer and multiple sclerosis. *[1]*

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A2. Infrared (IR) spectroscopy is widely used as a technique in analytical chemistry.

(a) Describe the operating principles of a double-beam infrared (IR) spectrometer. *[3]*

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(b) Explain what happens at a molecular level during the absorption of IR radiation by carbon dioxide, CO_2. *[3]*

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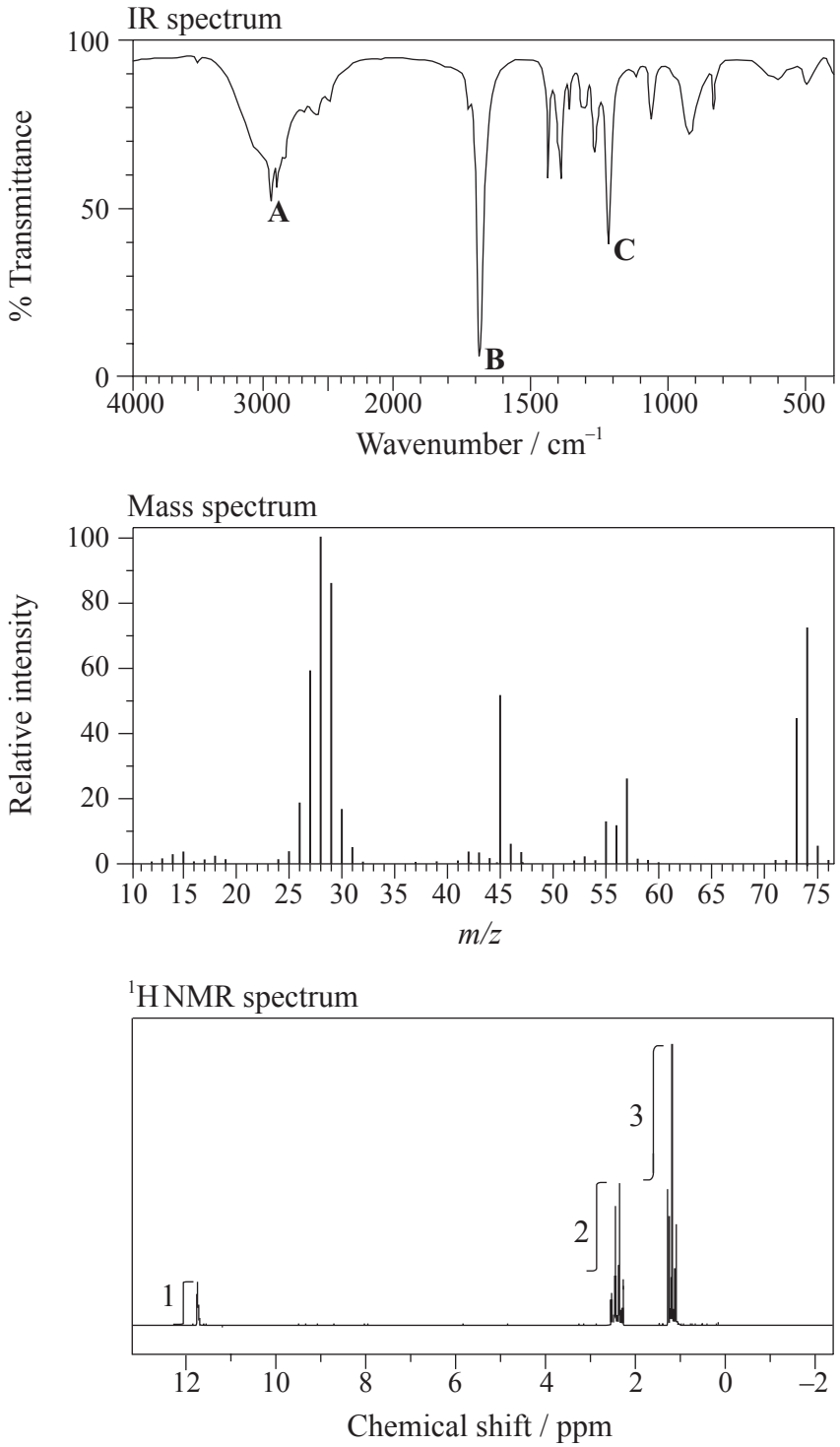
(Question A2 continued)

(c) The IR spectrum, mass spectrum and ^{1}H NMR spectrum of an unknown compound, **X**, of molecular formula $C_3H_6O_2$ are as follows.



[Source: SDBSWeb: http://riodb01.ibase.aist.go.jp/sdbs/ (National Institute of Advanced Industrial Science and Technology)]

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(Question A2 continued)

(i) Identify the bonds responsible for the peaks **A**, **B** and **C** in the IR spectrum of **X**. *[2]*

A: . . . . . .

B: . . . . . .

C: . . . . . .

(ii) In the mass spectrum of **X**, deduce which ions the *m/z* values at 74, 45 and 29 correspond to. *[3]*

$m/z = 74$: . . . . . .

$m/z = 45$: . . . . . .

$m/z = 29$: . . . . . .

(iii) Identify the peak at 11.73 ppm in the ^{1}H NMR spectrum. *[1]*

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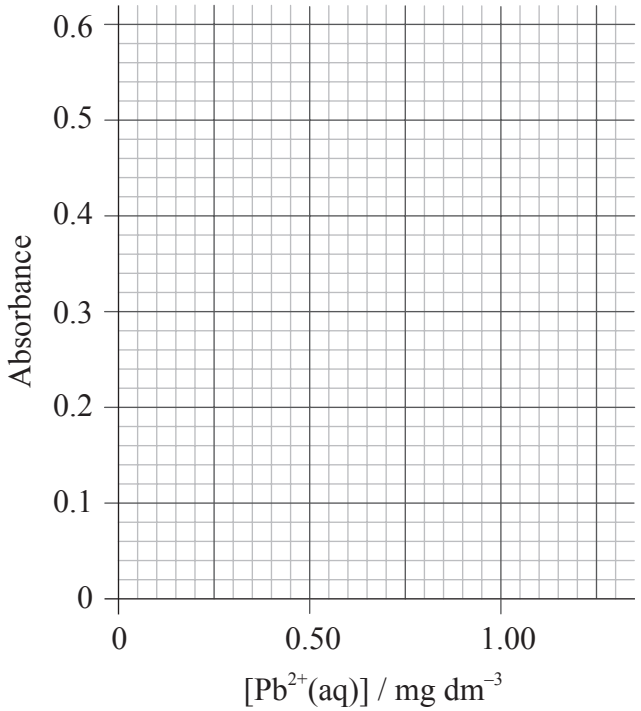
(iv) Deduce the structure of **X**. *[1]*

A3. According to recommendations from the *World Health Organization* (WHO), the maximum allowed concentration of lead(II) cations, $Pb^{2+}(aq)$, in drinking water is 0.001 mg dm^{-3}. The tap water taken from a building was analysed using atomic absorption (AA) spectroscopy to determine the concentration of $Pb^{2+}(aq)$. An AA spectrophotometer was calibrated and the following results were obtained.

$[Pb^{2+}(aq)]$ / mg dm^{-3}	**Absorbance**
0.25	0.110
0.50	0.220
0.75	0.340
1.00	0.450
1.25	0.560
Sample	0.170

Draw the calibration curve and determine whether or not the water is within the WHO recommended maximum allowed concentration of lead(II) cations. *[3]*



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Option B — Human biochemistry

B1. Foods such as rice, bread and potatoes are rich in carbohydrates. There are three main types of carbohydrate – monosaccharides, disaccharides and polysaccharides.

(a) Glucose, $C_6H_{12}O_6$, is a monosaccharide. When 0.85 g of glucose was completely combusted in a calorimeter, the temperature of 200.10 g of water increased from 20.20 °C to 27.55 °C. Calculate the energy value of glucose in J g^{-1}. *[3]*

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(b) (i) Draw the straight chain structure of glucose. *[1]*

(ii) Draw the structural formula of α-glucose. *[1]*

(iii) Distinguish between the structures of α- and β-glucose. *[1]*

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(This question continues on the following page)

(Question B1 continued)

(iv) Two α-glucose molecules condense to form the disaccharide maltose. Deduce the structure of maltose. *[1]*

(c) One of the major functions of carbohydrates in the human body is as an energy source. State **one** other function of a carbohydrate. *[1]*

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B2. (a) Linoleic acid is an essential fatty acid whose formula is given in Table 22 of the Data Booklet. Determine the mass of iodine, I_2, which reacts with 100 g of linoleic acid. *[3]*

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(b) Fats, such as butter, are solid triglycerides. Explain why fats have a higher energy value than carbohydrates. *[1]*

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(c) The formula of stearic acid is also given in Table 22 of the Data Booklet. Explain why linoleic acid has a lower melting point compared to stearic acid. *[2]*

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B3. Steroidal-based hormones such as estradiol, progesterone and testosterone all contain a common structure.

(a) State what is meant by the term *hormone*. *[1]*

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(b) The structures of estradiol, progesterone and testosterone are given in Table 21 of the Data Booklet.

(i) State the names of **two** different functional groups present in progesterone but absent in estradiol. *[2]*

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(ii) Deduce the number of hydrogen atoms joined directly to the carbon atoms as part of the steroidal backbone in progesterone. *[1]*

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(c) The male steroidal hormones can be described as androgens. Testosterone is one such hormone. State **two** medical uses of testosterone as a steroid. *[2]*

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Option C — Chemistry in industry and technology

C1. "Oil should not be used as a source of energy because it has more important uses." Suggest **two** arguments that support the continued use of oil as an energy source, and **two** against. *[4]*

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C2. Thermal cracking, catalytic cracking and steam cracking are all used to convert alkane molecules into smaller molecules. Identify which **one** of the three types of cracking is used to crack a hexane molecule, C_6H_{14}, into propane and an alkene molecule, and state the equation involved. *[2]*

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C3. Exciting developments have taken place in recent years in the area of nanotechnology.

(a) Define the term *nanotechnology*, and state why it is of interest to chemists. *[2]*

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(b) Carbon nanotubes can be used to make *designer catalysts*.

(i) Describe the structure of carbon nanotubes. *[2]*

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(ii) State **one** physical property of carbon nanotubes. *[1]*

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(c) Suggest **two** concerns about the use of nanotechnology. *[2]*

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C4. (a) State the half-equations for the reactions taking place at the negative electrode (anode) and the positive electrode (cathode) in an alkaline hydrogen-oxygen fuel cell. *[2]*

Negative electrode (anode):

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Positive electrode (cathode):

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(b) A different type of cell has the half-equation below.

$$Li^+(polymer) + MnO_2(s) + e^- \rightarrow LiMnO_2(s)$$

Identify this type of cell. *[1]*

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(c) Both fuel cells and rechargeable batteries offer great potential for the future. Compare these two power sources. *[2]*

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(d) Suggest **two** problems associated with using hydrogen gas in a fuel cell. *[2]*

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Option D — Medicines and drugs

D1. Dyspepsia, commonly known as indigestion, is due to excess acid in the stomach and can be treated using antacids.

(a) State the name of the acid found in the gastric juices of the stomach. *[1]*

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(b) Two examples of antacids are aluminium hydroxide and calcium carbonate. State the equations to show the action of each antacid. *[2]*

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(c) Antacid medicines often contain alginates and anti-foaming agents.

(i) Explain briefly how alginates prevent heartburn. *[2]*

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(ii) Explain why anti-foaming agents are added and state **one** example. *[2]*

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D2. (a) Two examples of mild analgesics are aspirin and paracetamol (acetaminophen). Paracetamol is often used as an alternative to aspirin. State **one** advantage and **one** disadvantage of the use of paracetamol. *[2]*

Advantage:

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Disadvantage:

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(b) Examples of strong analgesics are morphine, codeine and diamorphine (heroin). Their structures are shown in Table 20 of the Data Booklet.

(i) Identify **two** functional groups present in all three of these analgesics. *[2]*

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(ii) Identify **one** functional group present in morphine, but not in diamorphine. *[1]*

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(iii) State the name of the type of chemical reaction which is used to convert morphine into diamorphine. *[1]*

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D3. AIDS (acquired immune deficiency syndrome) has resulted in millions of deaths worldwide since it was first recorded in 1981. The control and treatment of HIV is made worse by the high price of anti-retroviral agents and sociocultural issues. Discuss **one** sociocultural difficulty facing society today associated with solving this global problem. *[3]*

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D4. (a) State **one** difference between viruses and bacteria. *[1]*

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(b) Discuss **three** methods in which the activities of humans has created an increase in the resistance to penicillin in bacteria populations. *[3]*

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Option E — Environmental chemistry

E1. Motor cars are convenient but produce pollution.

(a) List **three** pollutants, other than carbon dioxide, that are produced in the combustion engines of motor cars. *[3]*

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(b) Pollution can be decreased with the use of a catalytic converter. State an equation for **one** reaction that occurs in a catalytic converter. *[1]*

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(c) For the three pollutants that you listed in part (a), describe the polluting effect of each. An example has been given. *[3]*

Pollutant	Effect
Carbon dioxide	*Contributes to global warming*

E2. The quality of water can be affected by thermal pollution. State **one** major source of this pollution and discuss its effect on fish. *[3]*

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E3. One of the main causes of soil degradation is nutrient depletion.

(a) (i) State what you understand by the term *nutrient* when used in the context of soils. *[1]*

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(ii) Explain how agriculture removes soil nutrients and how they can be replaced. *[2]*

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(b) The organic constituents of the soil are important. State the chemical term used to describe them, and explain how they affect the physical quality of the soil. *[2]*

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E4. Radioactive waste must be disposed of with care.

(a) State what is meant by the term *high-level* radioactive waste. *[1]*

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(b) (i) Explain why high-level waste should **not** be disposed of by landfill or incineration. *[2]*

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(ii) State the name of **one** method of disposal used for high-level waste and explain why such a method is better than landfill and incineration. *[2]*

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Option F — Food chemistry

F1. (a) List **four** main factors that cause foods to spoil. *[2]*

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(b) Describe the rancidity of fats. *[2]*

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F2. (a) Distinguish between a *food dye* and a *food pigment*. *[2]*

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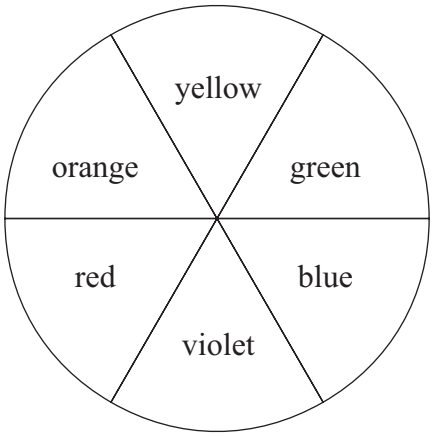
(b) The pigment in blueberries is an anthocyanin.



(i) With reference to the colour wheel above, explain how the pigment in blueberries causes them to be blue. *[2]*

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(ii) List **two** other fruits that contain significant amounts of anthocyanin(s). *[2]*

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(iii) State the combination of pH and temperature that produces the strongest colour in anthocyanins. *[1]*

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F3. The compound olestra has similar properties to saturated fats. It is used in margarine and related products, but it is not digested in the human gut. It is made from a disaccharide with up to eight fatty acid groups attached to it.

(a) (i) Explain what feature of the structure of glycerol (propane-1,2,3-triol) allows fatty acid molecules to become attached to it to make fats, and state the name of the reaction by which this occurs. *[2]*

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(ii) The structure of lactose, a typical disaccharide, is given in Table 21 of the Data Booklet. Suggest a reason why fatty acids can be attached to it. *[1]*

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(b) The fatty acids in olestra are smaller than those in cooking fats. Suggest a reason for this. *[1]*

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F4. (a) Define the term *genetically modified* (GM) *food*. *[1]*

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(b) Discuss the benefits and concerns of using GM foods. *[4]*

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Option G — Further organic chemistry

G1. (a) Describe the structure of benzene, C_6H_6. *[3]*

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(b) State **two** pieces of evidence that support this description. *[2]*

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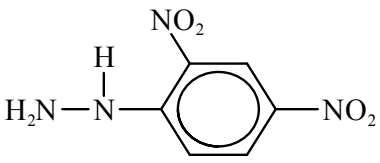
G2. Draw the structural formula of the **major** organic products, **A** and **B**, formed in the following reactions.

(a) $CH_3CH_2CH{=}CH_2 + HBr \rightarrow \mathbf{A}$ *[1]*

A:

(b) $CH_3CH_2COCH_3 +$  $\xrightarrow{H^+} \mathbf{B}$ *[1]*

B:

G3. (a) Deduce a two-step reaction pathway which can be used to convert 1-bromopropane into butanoic acid. Draw the structural formula of the organic product formed for each step and identify the reagents involved. *[4]*

(b) Deduce a two-step reaction pathway which can be used to convert propan-2-ol into 1,2-dibromopropane. Draw the structural formula of the organic product formed for each step and identify the reagents involved. *[4]*

G4. (a) State and explain which of the two compounds, phenol or ethanol, is the stronger acid. *[2]*

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(b) State and explain which of the two compounds, ethanoic acid or chloroethanoic acid, is the stronger acid. *[3]*

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