22096111

International Baccalaureate®
Baccalauréat International
Bachillerato Internacional

CHEMISTRY
STANDARD LEVEL
PAPER 2

Monday 18 May 2009 (afternoon)

1 hour 15 minutes

Candidate session number

0	0							

INSTRUCTIONS TO CANDIDATES

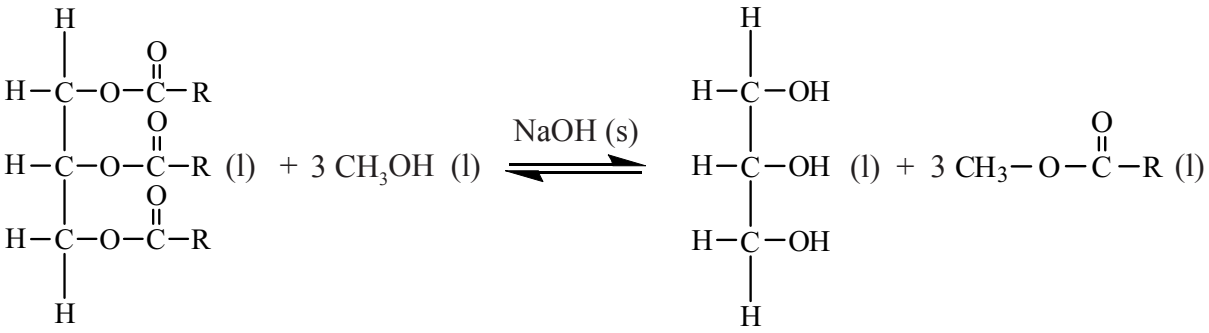
- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all of Section A in the spaces provided.
- Section B: answer one question from Section B. Write your answers on answer sheets. Write your session number on each answer sheet, and attach them to this examination paper and your cover sheet using the tag provided.
- At the end of the examination, indicate the numbers of the questions answered in the candidate box on your cover sheet and indicate the number of sheets used in the appropriate box on your cover sheet.

0113

SECTION A

*Answer **all** the questions in the spaces provided.*

1. Biodiesel makes use of plants' ability to fix atmospheric carbon by photosynthesis. Many companies and individuals are now using biodiesel as a fuel in order to reduce their carbon footprint. Biodiesel can be synthesized from vegetable oil according to the following reaction.



vegetable oil methanol glycerol biodiesel

(a) Identify the organic functional group present in both vegetable oil and biodiesel. *[1]*

. . . . . .

(b) For part of her extended essay investigation into the efficiency of the process, a student reacted a pure sample of a vegetable oil (where $R = C_{17}H_{33}$) with methanol. The raw data recorded for the reaction is below.

Mass of oil	= 1013.0 g
Mass of methanol	= 200.0 g
Mass of sodium hydroxide	= 3.5 g
Mass of biodiesel produced	= 811.0 g

The relative molecular mass of the oil used by the student is 885.6. Calculate the amount (in moles) of the oil and the methanol used, and hence the amount (in moles) of excess methanol. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(c) The reversible arrows in the equation indicate that the production of biodiesel is an equilibrium process.

(i) State what is meant by the term *dynamic equilibrium*. *[1]*

. . . . . .

. . . . . .

(ii) Using the abbreviations [vegetable oil], [methanol], [glycerol] and [biodiesel] deduce the equilibrium constant expression (K_c) for this reaction. *[1]*

(iii) Suggest a reason why excess methanol is used in this process. *[1]*

. . . . . .

. . . . . .

(iv) State and explain the effect that the addition of the sodium hydroxide catalyst will have on the position of equilibrium. *[2]*

. . . . . .

. . . . . .

. . . . . .

(d) The reactants had to be stirred vigorously because they formed two distinct layers in the reaction vessel. Explain why they form two distinct layers and why stirring increases the rate of reaction. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(e) Calculate the percentage yield of biodiesel obtained in this process. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(f) When biodiesel is combusted it produces carbon dioxide. Explain why the use of biodiesel as a fuel does not significantly contribute to global warming. *[1]*

. . . . . .

. . . . . .

Blank page

2. Two students were asked to use information from the Data Booklet to calculate a value for the enthalpy of hydrogenation of ethene to form ethane.

$$C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$$

John used the average bond enthalpies from Table 10. Marit used the values of enthalpies of combustion from Table 12.

(a) Calculate the value for the enthalpy of hydrogenation of ethene obtained using the average bond enthalpies given in Table 10. *[2]*

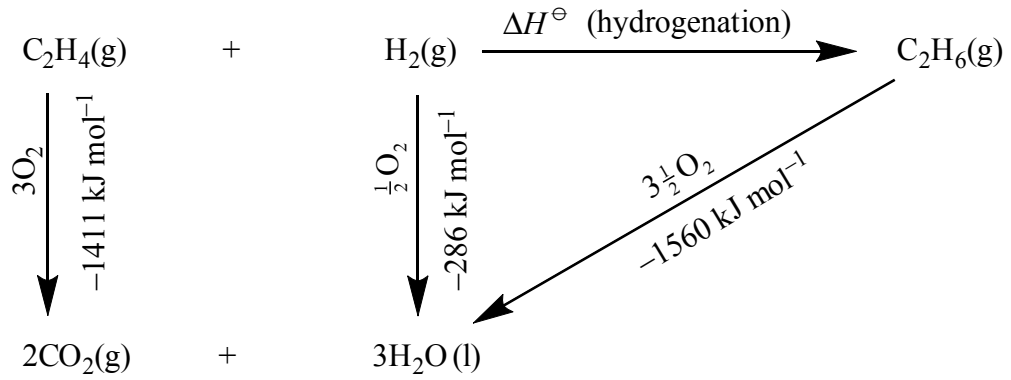
. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Marit arranged the values she found in Table 12 into an energy cycle.



Calculate the value for the enthalpy of hydrogenation of ethene from the energy cycle. *[1]*

. . . . . .

. . . . . .

. . . . . .

(c) Suggest **one** reason why John's answer is slightly less accurate than Marit's answer. *[1]*

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 2 continued)

(d) John then decided to determine the enthalpy of hydrogenation of cyclohexene to produce cyclohexane.

$$C_6H_{10}(l) + H_2(g) \rightarrow C_6H_{12}(l)$$

(i) Use the average bond enthalpies to deduce a value for the enthalpy of hydrogenation of cyclohexene. *[1]*

. . . . . .

. . . . . .

(ii) The percentage difference between these two methods (average bond enthalpies and enthalpies of combustion) is greater for cyclohexene than it was for ethene. John's hypothesis was that it would be the same. Determine why the use of average bond enthalpies is less accurate for the cyclohexene equation shown above, than it was for ethene. Deduce what extra information is needed to provide a more accurate answer. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

3. Sodium oxide, Na_2O, is a white solid with a high melting point.

(a) Explain why solid sodium oxide is a non-conductor of electricity. *[1]*

. . . . . .

. . . . . .

(b) Molten sodium oxide is a good conductor of electricity. State the half-equation for the reaction occurring at the positive electrode during the electrolysis of molten sodium oxide. *[1]*

. . . . . .

(c) (i) State the acid-base nature of sodium oxide. *[1]*

. . . . . .

(ii) State the equation for the reaction of sodium oxide with water. *[1]*

. . . . . .

4. (a) Define oxidation in terms of electron transfer. *[1]*

. . . . . .

. . . . . .

(b) Chlorine can be made by reacting concentrated hydrochloric acid with potassium manganate(VII), $KMnO_4$.

$$2KMnO_4(aq) + 16HCl(aq) \rightarrow 2MnCl_2(aq) + 2KCl(aq) + 5Cl_2(aq) + 8H_2O(aq)$$

(i) State the oxidation number of manganese in $KMnO_4$ and in $MnCl_2$. *[2]*

$KMnO_4$ . . . . . .

$MnCl_2$ . . . . . .

(ii) Deduce which species has been oxidized in this reaction and state the change in oxidation number that it has undergone. *[2]*

. . . . . .

. . . . . .

SECTION B

*Answer **one** question. Write your answers on the answer sheets provided. Write your session number on each answer sheet, and attach them to this examination paper and your cover sheet using the tag provided.*

5. (a) (i) Describe and explain the operation of a mass spectrometer. *[5]*

(ii) State **three** factors that affect the degree of deflection of ions in a mass spectrometer. *[3]*

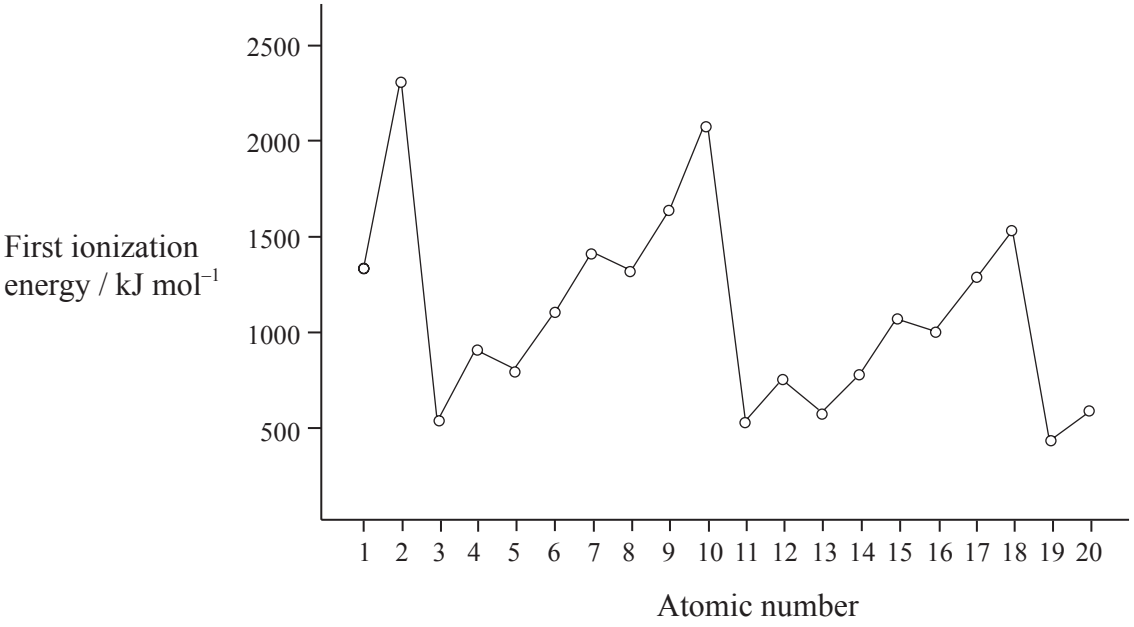
(iii) Strontium exists as four naturally-occurring isotopes. Calculate the relative atomic mass of strontium to two decimal places from the following data. *[2]*

Isotope	Percentage abundance
Sr-84	0.56
Sr-86	9.90
Sr-87	7.00
Sr-88	82.54

(This question continues on the following page)

(Question 5 continued)

(b) The graph of the first ionization energy plotted against atomic number for the first twenty elements shows periodicity.



(i) Define the term *first ionization energy* and state what is meant by the term *periodicity*. *[2]*

(ii) State the electron arrangement of argon and explain why the noble gases, helium, neon and argon show the highest first ionization energies for their respective periods. *[3]*

(iii) A graph of atomic radius plotted against atomic number shows that the atomic radius decreases across a period. Explain why chlorine has a smaller atomic radius than sodium. *[1]*

(iv) Explain why a sulfide ion, S^{2-}, is larger than a chloride ion, Cl^{-}. *[1]*

(v) Explain why the melting points of the Group 1 metals $(Li \rightarrow Cs)$ decrease down the group whereas the melting points of the Group 7 elements $(F \rightarrow I)$ increase down the group. *[3]*

6. (a) (i) Draw the Lewis structures for carbon monoxide, CO, carbon dioxide, CO_2 and methanol, CH_3OH. *[3]*

(ii) List, with an explanation, the three compounds in order of increasing carbon to oxygen bond length (shortest first). *[2]*

(b) Predict the shape and bond angles for the following species:

(i) CO_2 *[2]*

(ii) CO_3^{2-} *[2]*

(iii) BF_4^- *[2]*

(c) (i) Define a Brønsted-Lowry acid. *[1]*

(ii) Deduce the two acids and their conjugate bases in the following reaction:

$$H_2O(l) + NH_3(aq) \rightleftharpoons OH^-(aq) + NH_4^+(aq)$$ *[2]*

(iii) Explain why the following reaction can also be described as an acid-base reaction.

$$F^-(g) + BF_3(g) \rightleftharpoons BF_4^-(s)$$ *[2]*

(d) Ethanoic acid, CH_3COOH, is a weak acid.

(i) Define the term *weak acid* and state the equation for the reaction of ethanoic acid with water. *[2]*

(ii) Vinegar, which contains ethanoic acid, can be used to clean deposits of calcium carbonate from the elements of electric kettles. State the equation for the reaction of ethanoic acid with calcium carbonate. *[2]*

7. (a) Three compounds with similar relative molecular masses are butane, propanal and propan-1-ol.

(i) List the three compounds in order of increasing boiling point (lowest first) and explain the differences in their boiling points. *[4]*

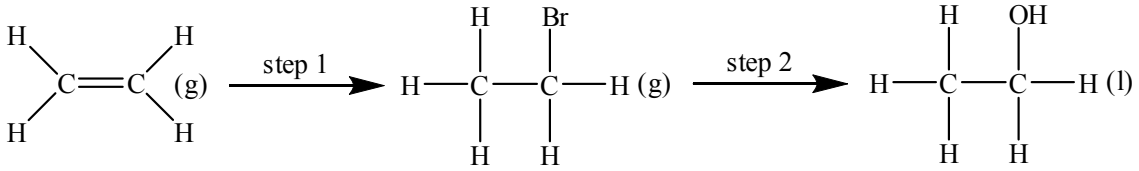
(ii) Predict, with an explanation, which of the three compounds is **least** soluble or miscible in water. *[2]*

(iii) When propan-1-ol is oxidized using a warm acidified solution of potassium dichromate(VI) two different organic products can be obtained. Deduce the name and structural formula for each of these two products. *[3]*

(iv) Propan-2-ol is an isomer of propan-1-ol. Draw the structure of propan-2-ol. *[1]*

(v) Identify the class of alcohols that propan-2-ol belongs to and state the name of the organic product formed when it is oxidized by an acidified solution of potassium dichromate(VI). *[2]*

(b) Ethanol can be formed from ethene in a two step reaction:



(i) State the name of the reagent used for step 1. *[1]*

(ii) State the name of the reagent and the conditions used for step 2. *[2]*

(iii) The mechanism involved in step 2 is S_N2. Explain how the reaction proceeds using curly arrows to represent the movement of electron pairs. *[3]*

(iv) Outline how ethanol is manufactured from ethene in industry and state **one** important commercial use of ethanol. *[2]*