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CHEMISTRY
STANDARD LEVEL
PAPER 2

Candidate session number

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Monday 9 May 2011 (afternoon)

1 hour 15 minutes

Examination code

2	2	1	1	–	6	1	1	1

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 questions.
- Section B: answer one question.
- Write your answers in the boxes provided.

Please **do not** write on this page.

Answers written on this page will not be marked.

SECTION A

*Answer **all** questions. Write your answers in the boxes provided.*

1. Methanol is made in large quantities as it is used in the production of polymers and in fuels. The enthalpy of combustion of methanol can be determined theoretically or experimentally.

$$CH_3OH(l) + 1\tfrac{1}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

(a) Using the information from Table 10 of the Data Booklet, determine the theoretical enthalpy of combustion of methanol. *[3]*

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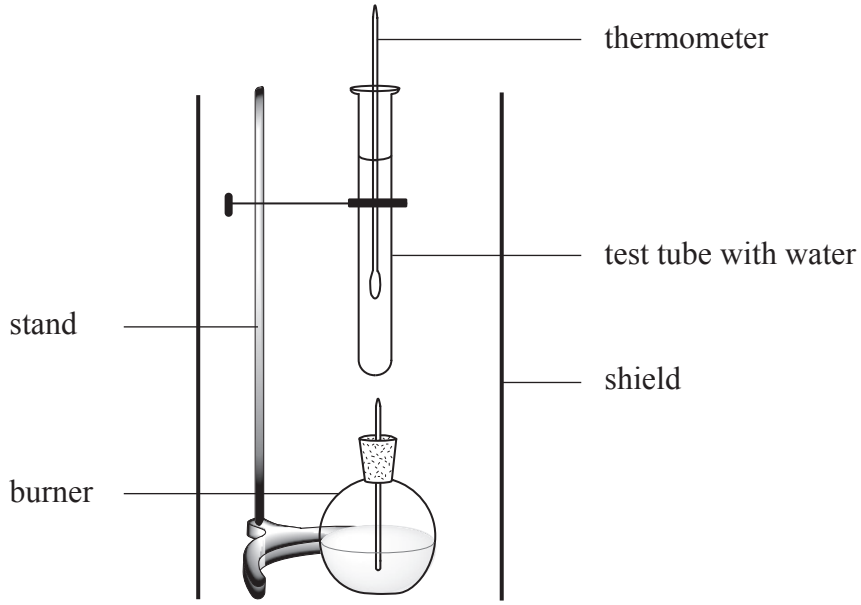
(Question 1 continued)

(b) The enthalpy of combustion of methanol can also be determined experimentally in a school laboratory. A burner containing methanol was weighed and used to heat water in a test tube as illustrated below.



The following data were collected.

Initial mass of burner and methanol / g	80.557
Final mass of burner and methanol / g	80.034
Mass of water in test tube / g	20.000
Initial temperature of water / °C	21.5
Final temperature of water / °C	26.4

(i) Calculate the amount, in mol, of methanol burned. *[2]*

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(Question 1 continued)

(ii) Calculate the heat absorbed, in kJ, by the water. *[3]*

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(iii) Determine the enthalpy change, in kJ mol^{-1}, for the combustion of 1 mole of methanol. *[2]*

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(Question 1 continued)

(c) The Data Booklet value for the enthalpy of combustion of methanol is –726 kJ mol^{-1}. Suggest why this value differs from the values calculated in parts (a) and (b).

(i) Part (a) *[1]*

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(ii) Part (b) *[1]*

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2. (a) Explain why the relative atomic mass of argon is greater than the relative atomic mass of potassium, even though the atomic number of potassium is greater than the atomic number of argon. *[1]*

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(b) Deduce the numbers of protons and electrons in the K^+ ion. *[1]*

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(c) Deduce the electron arrangement for the K^+ ion. *[1]*

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3. Methanol may be produced by the exothermic reaction of carbon monoxide gas and hydrogen gas.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H^{\ominus} = -103 \text{ kJ}$$

(a) State the equilibrium constant expression, K_c, for the production of methanol. *[1]*

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(b) State and explain the effect of changing the following conditions on the amount of methanol present at equilibrium:

(i) increasing the temperature of the reaction at constant pressure. *[2]*

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(ii) increasing the pressure of the reaction at constant temperature. *[2]*

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(Question 3 continued)

(c) The conditions used in industry during the production of methanol are a temperature of 450 °C and pressure of up to 220 atm. Explain why these conditions are used rather than those that could give an even greater amount of methanol. *[2]*

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(d) A catalyst of copper mixed with zinc oxide and alumina is used in industry for this production of methanol. Explain the function of the catalyst. *[1]*

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4. Ethanol is used as a component in fuel for some vehicles. One fuel mixture contains 10 % by mass of ethanol in unleaded petrol (gasoline). This mixture is often referred to as Gasohol E10.

(a) Assume that the other 90 % by mass of Gasohol E10 is octane. 1.00 kg of this fuel mixture was burned.

$$CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l) \qquad \Delta H^{\ominus} = -1367 \text{ kJ mol}^{-1}$$

$$C_8H_{18}(l) + 12\tfrac{1}{2}O_2(g) \rightarrow 8CO_2(g) + 9H_2O(l) \qquad \Delta H^{\ominus} = -5470 \text{ kJ mol}^{-1}$$

(i) Calculate the mass, in g, of ethanol and octane in 1.00 kg of the fuel mixture. *[1]*

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(ii) Calculate the amount, in mol, of ethanol and octane in 1.00 kg of the fuel mixture. *[1]*

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(iii) Calculate the total amount of energy, in kJ, released when 1.00 kg of the fuel mixture is completely burned. *[3]*

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(Question 4 continued)

(b) If the fuel blend was vaporized before combustion, predict whether the amount of energy released would be greater, less or the same. Explain your answer. *[2]*

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SECTION B

*Answer **one** question. Write your answers in the boxes provided.*

5. (a) (i) Define the term *first ionization energy*. *[2]*

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(ii) Explain why the first ionization energy of magnesium is higher than that of sodium. *[2]*

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(Question 5 continued)

(b) Explain why:

(i) calcium has a higher melting point than potassium. *[2]*

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(ii) sodium oxide has a higher melting point than sulfur trioxide. *[3]*

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(c) (i) Define the terms *acid* and *base* according to the Brønsted-Lowry theory **and** state **one** example of a weak acid and **one** example of a strong base. *[2]*

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(Question 5 continued)

(ii) Describe **two** different methods, one chemical and one physical, other than measuring the pH, that could be used to distinguish between ethanoic acid and hydrochloric acid solutions of the same concentration. *[4]*

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(iii) Black coffee has a pH of 5 and toothpaste has a pH of 8. Identify which is more acidic **and** deduce how many times the $[H^+]$ is greater in the more acidic product. *[2]*

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(d) Samples of sodium oxide and sulfur trioxide are added to separate beakers of water. Deduce the equation for **each** reaction **and** identify each oxide as acidic, basic or neutral. *[3]*

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6. Alkenes are important starting materials for a variety of products.

(a) State and explain the trend of the boiling points of the first five members of the alkene homologous series. *[3]*

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(b) Describe **two** features of a homologous series. *[2]*

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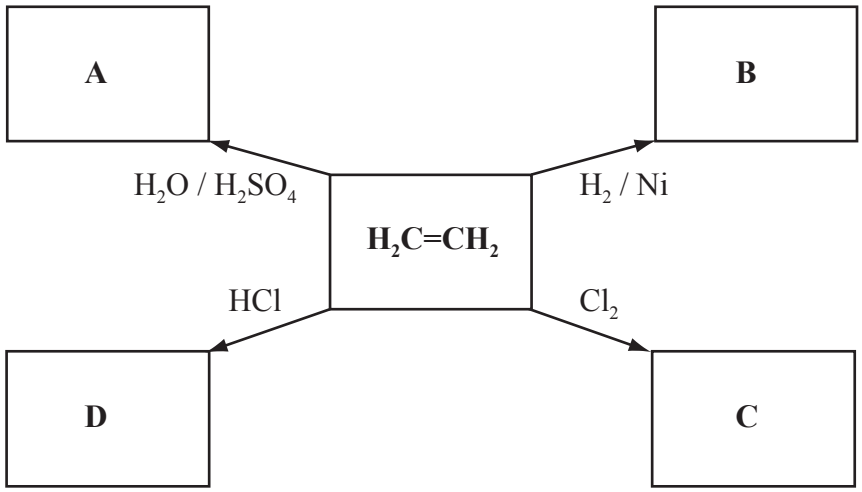
(Question 6 continued)

(c) Below is a schematic diagram representing some reactions of ethene. The letters **A**–**D** represent the organic compounds formed from the reactants and catalysts shown.



Deduce the structural formulas of compounds **A**, **B**, **C**, and **D** and state the IUPAC name of compound **C**. *[5]*

A:

B:

C:

IUPAC name: . . . . . .

D:

(This question continues on the following page)

(Question 6 continued)

(d) Describe a chemical test that could be used to distinguish between pent-1-ene and pentane. *[2]*

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(Question 6 continued)

(e) State and explain whether the following molecules are primary, secondary or tertiary halogenoalkanes. *[4]*

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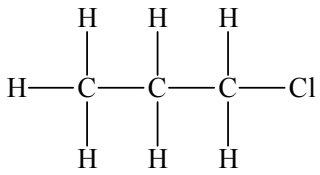

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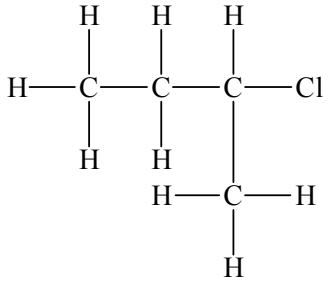

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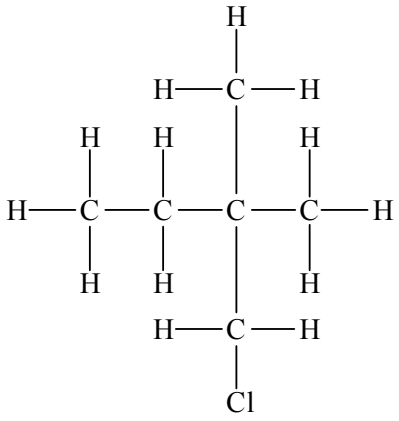

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(Question 6 continued)

(f) Explain, using equations, the following steps in the free-radical mechanism of the reaction of methane with chlorine. *[4]*

- Initiation
- Propagation
- Termination

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7. Carbon and silicon belong to the same group of the periodic table.

(a) Distinguish between the terms *group* and *period* in terms of electron arrangement. *[2]*

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(b) State the period numbers of both carbon and silicon. *[1]*

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(c) Describe and compare **three** features of the structure and bonding in the three allotropes of carbon: diamond, graphite and C_{60} fullerene. *[6]*

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(Question 7 continued)

(d) Both silicon and carbon form oxides.

(i) Draw the Lewis structure of CO_2 and predict its shape and bond angle. *[2]*

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(ii) Describe the structure and bonding in SiO_2. *[2]*

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(iii) Explain why silicon dioxide is a solid and carbon dioxide is a gas at room temperature. *[2]*

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(Question 7 continued)

(e) Describe the bonding within the carbon monoxide molecule. *[2]*

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(f) Silicon has three stable isotopes, ^{28}Si, ^{29}Si and ^{30}Si. The heaviest isotope, ^{30}Si, has a percentage abundance of 3.1 %. Calculate the percentage abundance of the lightest isotope to one decimal place. *[2]*

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(g) Identify a radioactive isotope of carbon and state **one** of its uses. *[1]*

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