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PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

M06/4/CHEMI/HP2/ENG/TZ0/XX

22066102

CHEMISTRY
HIGHER LEVEL
PAPER 2

Thursday 18 May 2006 (afternoon)

2 hours 15 minutes

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.
- Section A: answer all of Section A in the spaces provided.
- Section B: answer two questions 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.

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SECTION A

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

1. Hex-1-ene gas, C_6H_{12}, burns in oxygen to produce carbon dioxide and water vapour.

(a) Write an equation to represent this reaction. *[1]*

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(b) Use the data below to calculate the values of $\Delta H_c^{\ominus}$ and $\Delta S_c^{\ominus}$ for the combustion of hex-1-ene.

Substance	$O_2(g)$	$C_6H_{12}(g)$	$CO_2(g)$	$H_2O(g)$
Standard enthalpy of formation, $\Delta H_f^{\ominus}$ / kJ mol^{-1}	0.0	– 43	– 394	– 242
Entropy, S$^{\ominus}$/ J K^{-1} mol^{-1}	205	385	214	189

(i) Value of $\Delta H_c^{\ominus}$ *[2]*

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(ii) Value of $\Delta S_c^{\ominus}$ *[2]*

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(c) Calculate the standard free energy change for the combustion of hex-1-ene. *[2]*

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(Question 1 continued)

(d) State and explain whether or not the combustion of hex-1-ene is spontaneous at 25°C. *[1]*

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(e) Calculate the enthalpy change, ΔH_4 for the reaction *[4]*

$$C + 2H_2 + \tfrac{1}{2}O_2 \rightarrow CH_3OH \qquad \Delta H_4$$

using Hess's Law, and the following information.

$CH_3OH + 1\tfrac{1}{2}O_2 \rightarrow CO_2 + 2H_2O$ $\Delta H_1 = -676$ kJ mol^{-1}

$C + O_2 \rightarrow CO_2$ $\Delta H_2 = -394$ kJ mol^{-1}

$H_2 + \tfrac{1}{2}O_2 \rightarrow H_2O$ $\Delta H_3 = -242$ kJ mol^{-1}

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2. (a) Use the data below to calculate the relative molecular mass of thallium bromide, $TlBr_3$, to two decimal places. *[3]*

Isotope	Percentage Abundance
^{203}Tl	29.52
^{205}Tl	70.48
^{79}Br	50.69
^{81}Br	49.31

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(b) The value of the relative molecular mass of hydrogen bromide is 80.91, correct to two decimal places. Explain why no molecule in a sample of hydrogen bromide has this M_r value. *[2]*

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(c) State the full electron configuration for a bromide ion. *[1]*

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(d) Write the symbol for the ion with a 2+ charge which has the electron configuration of $1s^2 2s^2 2p^6$. *[1]*

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(e) Write the symbols for **three** other species, which also have the electron configuration of $1s^2 2s^2 2p^6$. *[2]*

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3. The reaction below represents the reduction of iron ore to produce iron.

$$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$$

A mixture of 30 kg of Fe_2O_3 and 5.0 kg of C was heated until no further reaction occurred. Calculate the maximum mass of iron that can be obtained from these masses of reactants. *[5]*

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4. (a) (i) Define *oxidizing agent* in terms of electron transfer. *[1]*

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(ii) Deduce the **change** in oxidation number of chromium in the reaction below. State with a reason whether the chromium has been oxidized or reduced. *[2]*

$$Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$$

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(b) Iron in food, in the form of Fe^{3+}, reacts with ascorbic acid (vitamin C), $C_6H_8O_6$, to form dehydroascorbic acid, $C_6H_6O_6$.

(i) Write an ionic half-equation to show the conversion of ascorbic acid to dehydroascorbic acid in aqueous solution. *[1]*

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(ii) In the other ionic half-equation Fe^{3+} is converted to Fe^{2+}. Deduce the overall equation for the reaction between $C_6H_8O_6$ and Fe^{3+}. *[1]*

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5. (a) State **two** characteristics of a homologous series. *[2]*

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(b) Describe a chemical test to distinguish between alkanes and alkenes, giving the result in each case. *[3]*

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(c) Some alcohols are oxidized by heating with acidified potassium dichromate(VI). If oxidation does occur, identify the possible oxidation products formed by each of the alcohols below. Indicate if no oxidation occurs. *[4]*

Butan–1–ol

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Butan–2–ol

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2–methylpropan–2–ol

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SECTION B

*Answer **two** questions. 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.*

6. Consider the following reaction in the Contact process for the production of sulfuric acid for parts (a) to (f) in this question.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

(a) Write the equilibrium constant expression for the reaction. *[1]*

(b) (i) State the catalyst used in this reaction of the Contact process. *[1]*

(ii) State and explain the effect of the catalyst on the value of the equilibrium constant and on the rate of the reaction. *[4]*

(c) Use the collision theory to explain why increasing the temperature increases the rate of the reaction between sulfur dioxide and oxygen. *[2]*

(d) Using Le Chatelier's principle explain the effect on the position of equilibrium of

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

(ii) removing sulfur trioxide. *[2]*

(e) Using the following data, explain whether the above reaction is exothermic or endothermic. *[2]*

Temperature / K	**Equilibrium constant K_c / dm^3 mol^{-1}**
298	9.77×10^{25}
500	8.61×10^{11}
700	1.75×10^{6}

(f) 1.50 mol of SO_2 and 2.00 mol of O_2 are placed in a 1.50 dm^3 flask and heated at 400 °C until equilibrium is reached. The final equilibrium mixture contained 0.500 mol of SO_3. Calculate the equilibrium constant, K_c of the reaction at this temperature, include units in your answer. *[5]*

(This question continues on the following page)

(Question 6 continued)

(g) (i) Using the data below, state and explain the relationship between enthalpy of vaporization and intermolecular forces. *[3]*

Substance	**Pentane**	**Propanoic acid**
Standard enthalpy of vaporization $\Delta H_v^{\ominus}$ / kJ mol^{-1}	27	57

(ii) Draw a graph to show how the vapour pressure of pentane changes as it is heated from its melting point to its boiling point. Explain this change in terms of the kinetic theory. *[3]*

7. (a) Draw the Lewis structures for the compounds XeF_4, PF_5 and BF_4^-. *[3]*

(b) Use the valance shell electron pair repulsion (VSEPR) theory to predict the shapes of the three compounds in (a). State and explain the bond angles in each of the three compounds. *[3]*

(c) State the meaning of the term hybridization. State the type of hybridization shown by the nitrogen atoms in N_2, N_2H_2 and N_2H_4. *[4]*

(d) By referring to the N_2H_2 molecule describe how sigma (σ) and pi (π) bonds form and describe how single and double bonds differ. *[4]*

(e) (i) Explain why the first ionization energy of magnesium is lower than that of fluorine. *[2]*

(ii) Write an equation to represent the third ionization energy of magnesium. Explain why the third ionization energy of magnesium is higher than that of fluorine. *[3]*

(f) (i) Explain why sodium has a lower melting point than magnesium. *[3]*

(ii) By referring to their structure and bonding explain why magnesium oxide has a higher melting point than sulfur dioxide. *[3]*

8. (a) (i) Define the term pH. *[1]*

(ii) A 25.0 cm^3 sample of 0.100 mol dm^{-3} hydrochloric acid was placed in a conical flask, and 0.100 mol dm^{-3} sodium hydroxide is added until a total of 50.0 cm^3 had been added. Sketch a graph of pH against volume of NaOH(aq) added, clearly showing the volume of NaOH(aq) needed for complete reaction and the pH values at the start, the equivalence point and finish. *[4]*

(iii) The experiment in (a) (ii) was repeated, but with a 25.0 cm^3 sample of 0.100 mol dm^{-3} ethanoic acid in the conical flask instead of the hydrochloric acid. Use information from Table 16 of the Data Booklet to calculate the pH at the start of the experiment. State the approximate pH value at the equivalence point. *[5]*

(b) (i) Describe how an indicator, HIn, works. *[3]*

(ii) Name a suitable indicator for the reaction between ethanoic acid and sodium hydroxide. Use information from Table 17 in the data booklet to explain your choice. *[2]*

(c) (i) Identify **two** substances that can be added to water to form a basic buffer solution. *[1]*

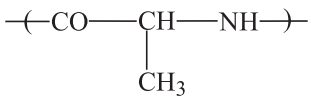
(ii) Describe what happens when a small amount of acid solution is added to the buffer solution prepared in (i). Use an equation to support your explanation. *[2]*

(d) Define the terms *Brønsted-Lowry acid* and *Lewis acid*. For each type of acid, identify one example other than water and write an equation to illustrate the definition. *[5]*

(e) Predict and explain whether an aqueous solution of 0.10 mol dm^{-3} $AlCl_3$ will be acidic, alkaline or neutral. *[2]*

9. (a) Given the structures of the repeating units of the polymers below, identify the monomers from which they are formed.

(i) $-(-CH_2-CH_2-)-$ *[1]*

(ii)  *[1]*

(iii) $-(-NH-(CH_2)_6-NH-CO-(CH_2)_4-CO-)-$ *[2]*

(b) Describe the essential difference between the structures of monomers that form addition polymers and the structures of monomers that form condensation polymers. *[2]*

(c) Draw and name an isomer of ethanoic acid, CH_3COOH. *[2]*

(d) (i) State the name of the reagent and the conditions required to convert ethanoic acid to methyl ethanoate. Write an equation for the reaction. *[3]*

(ii) Discuss **two** physical properties that differ for ethanoic acid and methyl ethanoate. *[2]*

(iii) Deduce the ratios of the areas under the peaks in the ^1H NMR spectrum of ethanoic acid and methyl ethanoate. *[2]*

(e) (i) There are **four** structural isomers with the formula C_4H_9Cl, one of which is optically active, $CH_3CHClCH_2CH_3$. State the name of this isomer and explain why it is optically active. *[2]*

(ii) Outline how the **two** optical isomers can be distinguished experimentally. *[2]*

(iii) Draw the structure of the **three** other structural isomers of C_4H_9Cl. *[2]*

(iv) Identify **one** isomer in (iii) that undergoes a substitution reaction mainly by a S_N2 mechanism. *[1]*

(v) Write the S_N2 mechanism for the reaction that occurs when the isomer identified in (iv) is warmed with aqueous sodium hydroxide. Use curly arrows to present the movement of electron pairs. *[3]*