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CHEMISTRY
STANDARD LEVEL
PAPER 2

Tuesday 3 November 2009 (afternoon)

1 hour 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 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.

0109

SECTION A

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

1. The data below is from an experiment used to determine the percentage of iron present in a sample of iron ore. This sample was dissolved in acid and all of the iron was converted to Fe^{2+}. The resulting solution was titrated with a standard solution of potassium manganate(VII), $KMnO_4$. This procedure was carried out three times. In acidic solution, MnO_4^- reacts with Fe^{2+} ions to form Mn^{2+} and Fe^{3+} and the end point is indicated by a slight pink colour.

Titre	**1**	**2**	**3**
Initial burette reading / cm^3	1.00	23.60	10.00
Final burette reading / cm^3	24.60	46.10	32.50

Mass of iron ore / g	3.682×10^{-1}
Concentration of $KMnO_4$ solution / mol dm^{-3}	2.152×10^{-2}

(a) Deduce the balanced redox equation for this reaction in **acidic** solution. *[2]*

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(b) Identify the reducing agent in the reaction. *[1]*

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(c) Calculate the amount, in moles, of MnO_4^- used in the titration. *[2]*

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(Question 1 continued)

(d) Calculate the amount, in moles, of Fe present in the 3.682×10^{-1} g sample of iron ore. *[2]*

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(e) Determine the percentage by mass of Fe present in the 3.682×10^{-1} g sample of iron ore. *[2]*

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2. PF_3, SF_2 and SiF_4 have different shapes. Draw their Lewis structures and use the VSEPR theory to predict the name of the shape of each molecule. *[6]*

	PF_3	SF_2	SiF_4
Lewis structure			
Name of shape	. . . . .	. . . . .	. . . . .

3. The standard enthalpy change of three combustion reactions is given below in kJ.

$$2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l) \qquad \Delta H^{\ominus} = -3120$$
$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l) \qquad \Delta H^{\ominus} = -572$$
$$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l) \qquad \Delta H^{\ominus} = -1411$$

Based on the above information, calculate the standard change in enthalpy, $\Delta H^{\ominus}$, for the following reaction.

$$C_2H_6(g) \rightarrow C_2H_4(g) + H_2(g)$$ *[4]*

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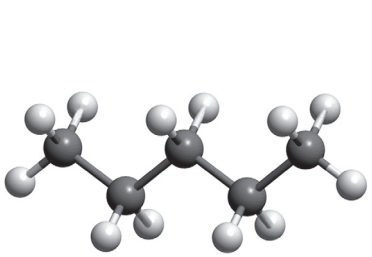
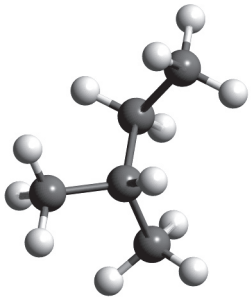
4. (a) The boiling points of the isomers of pentane, C_5H_{12}, shown are 10, 28 and 36 °C, but not necessarily in that order.



A



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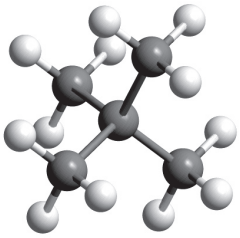

C

(i) Identify the boiling points for each of the isomers **A**, **B** and **C** and state a reason for your answer. *[3]*

Isomer	**A**	**B**	**C**
Boiling point			

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(ii) State the IUPAC names of isomers **B** and **C**. *[2]*

B: . . . . . .

C: . . . . . .

(b) Both C_5H_{12} and $C_5H_{11}OH$ can be used as fuels. Predict which compound would release a greater amount of heat per gram when it undergoes complete combustion. Suggest **two** reasons to support your prediction. *[3]*

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(Question 4 continued)

(c) In many cities around the world, public transport vehicles use diesel, a liquid hydrocarbon fuel, which often contains sulfur impurities and undergoes incomplete combustion. All public transport vehicles in New Delhi, India, have been converted to use compressed natural gas (CNG) as fuel. Suggest **two** ways in which this improves air quality, giving a reason for your answer. *[3]*

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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) Consider the following reaction taking place at 375 °C in a 1.00 dm^3 closed container.

$$Cl_2(g) + SO_2(g) \rightleftharpoons SO_2Cl_2(g) \qquad \Delta H^{\ominus} = -84.5 \text{ kJ}$$

(i) Deduce the equilibrium constant expression, K_c, for the reaction. *[1]*

(ii) If the temperature of the reaction is changed to 300 °C, predict, stating a reason in each case, whether the equilibrium concentration of SO_2Cl_2 and the value of K_c will increase or decrease. *[3]*

(iii) If the volume of the container is changed to 1.50 dm^3, predict, stating a reason in each case, how this will affect the equilibrium concentration of SO_2Cl_2 and the value of K_c. *[3]*

(iv) Suggest, stating a reason, how the addition of a catalyst at constant pressure and temperature will affect the equilibrium concentration of SO_2Cl_2. *[2]*

(b) Graphing is an important method in the study of the rates of chemical reaction. Sketch a graph to show how the reactant concentration changes with time in a typical chemical reaction taking place in solution. Show how the rate of the reaction at a particular time can be determined. *[4]*

(c) A solution of hydrogen peroxide, H_2O_2, is added to a solution of sodium iodide, NaI, acidified with hydrochloric acid, HCl. The yellow colour of the iodine, I_2, can be used to determine the rate of reaction.

$$H_2O_2(aq) + 2NaI(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + I_2(aq) + 2H_2O(l)$$

The experiment is repeated with some changes to the reaction conditions. For each of the changes that follow, predict, stating a reason, its effect on the rate of reaction.

(i) The concentration of H_2O_2 is increased at constant temperature. *[2]*

(ii) The solution of NaI is prepared from a fine powder instead of large crystals. *[2]*

(d) Explain why the rate of a reaction increases when the temperature of the system increases. *[3]*

6. (a) The equations of two acid-base reactions are given below.

Reaction **A** $NH_3(aq) + H_2O(l) \rightleftharpoons \underline{NH_4^+(aq)} + OH^-(aq)$

The reaction mixture in **A** consists mainly of reactants because the equilibrium lies to the left.

Reaction **B** $NH_2^-(aq) + H_2O(l) \rightleftharpoons \underline{NH_3(aq)} + OH^-(aq)$

The reaction mixture in **B** consists mainly of products because the equilibrium lies to the right.

(i) For each of the reactions **A** and **B**, deduce whether water is acting as an acid or a base and explain your answer. *[2]*

(ii) In reaction **B**, identify the stronger base, NH_2^- or OH^- and explain your answer. *[2]*

(iii) In reactions **A** and **B**, identify the stronger acid, NH_4^+ or NH_3 (underlined) and explain your answer. *[2]*

(b) Describe **two** different experimental methods to distinguish between aqueous solutions of a strong base and a weak base. *[5]*

(c) Two acidic solutions, **X** and **Y**, of equal concentrations have pH values of 2 and 6 respectively.

(i) Calculate the hydrogen ion concentrations in the two solutions and identify the stronger acid. *[2]*

(ii) Determine the ratio of the hydrogen ion concentrations in the two solutions **X** and **Y**. *[1]*

(d) (i) Define a Lewis acid and state an example that is not a Brønsted-Lowry acid. *[2]*

(ii) Draw structural formulas to represent the reaction between the Lewis acid named in (d) (i) and a Lewis base and identify the nature of the bond formed in the product. *[4]*

7. (a) Halogenoalkanes can undergo substitution reactions with potassium hydroxide solution.

(i) State an equation for the reaction of C_4H_9Cl with KOH. *[1]*

(ii) Substitution reactions may occur by either of two mechanisms namely S_N1 or S_N2. Outline the meaning of the term S_N1. *[2]*

(iii) Predict the mechanism (S_N1 or S_N2) expected for the reaction of the following halogenoalkanes with aqueous KOH.
1-chlorobutane to form butan-1-ol
2-chloro-2-methylpropane to form 2 methylpropan-2-ol. *[2]*

(iv) Explain the mechanism of each reaction in part (a) (iii) using curly arrows to represent the movement of electron pairs. *[6]*

(b) (i) Draw four structural isomers of molecular formula $C_4H_{10}O$ which contain the –OH group. *[4]*

(ii) On reaction with acidified potassium dichromate(VII), two of the isomers are oxidised in two steps to produce different products. Draw the structural formula of the **two** products formed from one of the isomers. *[2]*

(iii) A third isomer is oxidized in one step. Draw the structural formula of the organic product formed. *[1]*

(iv) State the colour change that takes place in these oxidation reactions. *[1]*

(v) Identify the isomer which resists oxidation by acidified potassium dichromate(VI). *[1]*