IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

N07/4/CHEMI/HP2/ENG/TZ0/XX+

88076102

CHEMISTRY
HIGHER LEVEL
PAPER 2

Wednesday 14 November 2007 (afternoon)

2 hours 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 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.

0112

SECTION A

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

1. 0.502 g of an alkali metal sulfate is dissolved in water and excess barium chloride solution, $BaCl_2(aq)$ is added to precipitate all the sulfate ions as barium sulfate, $BaSO_4(s)$. The precipitate is filtered and dried and weighs 0.672 g.

(a) Calculate the amount (in mol) of barium sulfate formed. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Determine the amount (in mol) of the alkali metal sulfate present. *[1]*

. . . . . .

(c) Determine the molar mass of the alkali metal sulfate and state its units. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(d) Deduce the identity of the alkali metal, showing your workings. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(e) Write an equation for the precipitation reaction, including state symbols. *[2]*

. . . . . .

. . . . . .

2. (a) Naturally occurring copper has a relative atomic mass, (A_r) of 63.55 and consists of two isotopes ^{63}Cu and ^{65}Cu.

(i) Define the term *relative atomic mass*, A_r. *[1]*

. . . . . .

. . . . . .

. . . . . .

(ii) State and explain which is the more abundant isotope. *[1]*

. . . . . .

. . . . . .

. . . . . .

(b) (i) Explain why successive ionization energies of an element increase. *[1]*

. . . . . .

. . . . . .

(ii) Explain how successive ionization energies account for the existence of three main energy levels in the sodium atom. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) State the formula of a stable ion formed from elemental vanadium. Identify which electrons are lost when the ion forms. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

3. Two flasks of equal volume are at the same temperature. One contains oxygen gas and the other contains an equal mass of methane gas.

(a) Compare the average kinetic energy of oxygen molecules with those of methane molecules and explain your reasoning. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Identify whether oxygen **or** methane molecules will have the **greater** average velocity at this temperature and explain your choice. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) Deduce whether the pressure in the flask containing methane is less than, greater than, **or** equal to, the pressure in the flask containing oxygen. Explain your choice. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

4. (a) Iodide ions, $I^-(aq)$, react with iodate ions, $IO_3^-(aq)$, in an acidic solution to form molecular iodine and water.

(i) Determine the oxidation number of iodine in I^- and in IO_3^-. *[1]*

. . . . . .

(ii) Identify, with a reason, the species that undergoes: *[2]*

oxidation . . . . . .

. . . . . .

reduction . . . . . .

. . . . . .

(iii) Write an ionic equation for the reaction of I^- with IO_3^- in an acidic solution. *[2]*

. . . . . .

. . . . . .

. . . . . .

(b) Use information from Table 15 of the Data Booklet to calculate the cell potential for the following reaction and state whether or not the reaction is spontaneous. *[3]*

$$Cu(s) + Cu^{2+}(aq) \rightarrow 2Cu^{+}(aq)$$

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

5. (a) (i) Draw the structural formula of the ester propyl ethanoate. *[1]*

(ii) Deduce the name and draw the structural formula of the alcohol and carboxylic acid that react to form this ester. *[4]*

Name of alcohol: . . . . . .

Structural formula:

Name of carboxylic acid:. . . . . .

Structural formula:

(b) (i) Draw the structural formula of propan-2-ol. *[1]*

(ii) Identify the alcohol as primary, secondary, **or** tertiary. *[1]*

. . . . . .

(iii) Identify the organic product formed by the oxidation of this alcohol using acidified potassium dichromate(VI) solution. *[1]*

. . . . . .

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. (a) Explain why sulfur has a lower first ionization energy than oxygen, and also a lower first ionization energy than phosphorus. *[4]*

(b) With reference to the types of bonding present in period 3 elements:

(i) explain why Mg has a higher melting point than Na. *[2]*

(ii) explain why Si has a very high melting point. *[2]*

(iii) explain why the other non-metal elements of period 3 have low melting points. *[2]*

(c) (i) Explain why complexes of Zn^{2+} are colourless whereas complexes containing Cu^{2+} are coloured. *[3]*

(ii) Give the formula and describe the shape of the complex ion formed between Fe^{3+} and the ligand CN^-. *[2]*

(d) (i) Draw a Lewis structure for each of two isomers with molecular formula $C_2H_4O_2$. *[2]*

(ii) Identify the more volatile isomer and explain your reasoning. *[2]*

(e) Deduce the shape of, and the bond angle in, the species XeF_2 and BrF_2^+, and explain your reasoning. *[6]*

7. (a) (i) Define the term *standard enthalpy change of formation,* $\Delta H_f^{\ominus}$. *[2]*

(ii) Construct a simple enthalpy cycle and calculate the value of $\Delta H_f^{\ominus}$ (C_2H_5OH (l)) given the following data. *[5]*

Compound	$\Delta H_f^{\ominus}$ / kJ mol^{-1}	$\Delta H_{comb}^{\ominus}$ / kJ mol^{-1}
H_2O (l)	–286	
CO_2 (g)	–394	
C_2H_5OH (l)		–1371

(b) (i) Define the term *average bond enthalpy*. *[2]*

(ii) The equation for the reaction of ethyne and hydrogen is:

$$C_2H_2(g) + 2H_2(g) \rightarrow C_2H_6(g)$$

Use information from Table 10 of the Data Booklet to calculate the change in enthalpy for the reaction. *[2]*

(iii) State and explain the trend in the bond enthalpies of the C–Cl, C–Br and C–I bonds. *[2]*

(c) (i) Define the term *molecularity*. State the molecularity for an S_N1 and S_N2 mechanism. *[2]*

(ii) Give the mechanism for the reaction of C_2H_5Cl with OH^- ions, using curly arrows to represent the movement of electron pairs. *[4]*

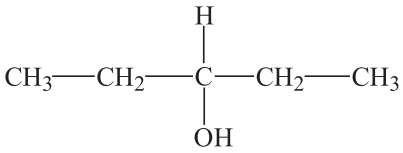
(iii) State how the rate of nucleophilic substitution changes if OH^- ions react with C_2H_5Cl, C_2H_5Br and C_2H_5I respectively. *[1]*

(iv) State how the rate of nucleophilic substitution depends on whether it is a primary, secondary **or** tertiary halogenoalkane. *[1]*

(This question continues on the following page)

(Question 7 continued)

(d) For pentan-3-ol,



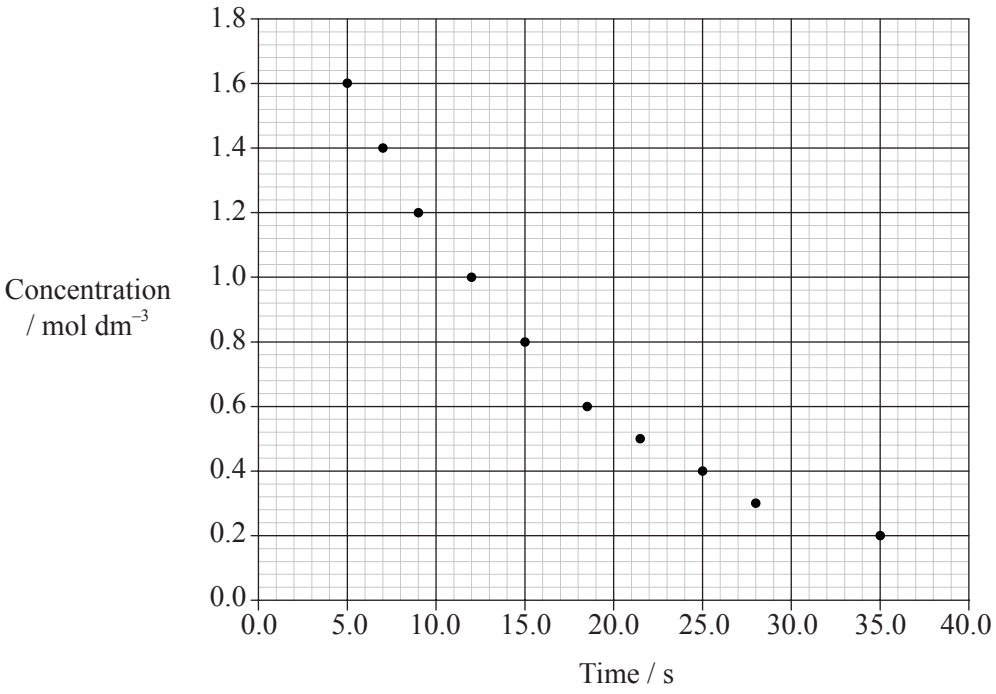
(i) deduce the number of peaks and their relative areas in its ^{1}H NMR spectrum. *[2]*

(ii) suggest **three** wave number ranges in which this compound will absorb infrared radiation. *[2]*

8. (a) (i) The reaction between propanone, CH_3COCH_3 and bromine, Br_2 in the presence of acid, H^+, is found to be second order overall, but the rate is independent of the bromine concentration. Write **three** possible rate expressions for the reaction. *[3]*

(ii) The concentration of each of the three reactants was doubled in three separate experiments. Choose **one** of the rate expressions in (a) (i) and predict the effect on the rate of the reaction of each of these changes. *[2]*

(iii) The graph below shows how the concentration of propanone changes with time in a reaction.



Use the graph to confirm that the reaction is first order with respect to propanone showing your working. *[2]*

(iv) The overall reaction is:

$$CH_3COCH_3(aq) + Br_2(aq) \xrightarrow{H^+(aq)} CH_3COCH_2Br(aq) + HBr(aq)$$

Describe **one** observation that would allow you to follow the progress of the reaction. State and explain the role of the acid in the reaction. *[4]*

(This question continues on the following page)

(Question 8 continued)

(b) In the gaseous state, methane and steam react to form hydrogen and carbon dioxide.

(i) Write an equation for the endothermic equilibrium reaction. Deduce the equilibrium expression for the reaction and state its units. *[4]*

(ii) Deduce and explain the conditions of temperature and pressure under which the forward reaction is favoured. *[4]*

(iii) Explain, at the molecular level, why the reaction is carried out at high pressure in industry. *[2]*

(iv) 1.0 mol methane and 3.0 mol steam are placed in a 1.0 dm^3 container and after equilibrium is reached, 2.0 mol hydrogen gas are present. Calculate the amount of each reactant and product at equilibrium, and thus determine the value of K_c for the reaction. *[4]*

9. (a) A solution containing ammonia requires 25.0 cm^3 of 0.100 mol dm^{-3} hydrochloric acid to reach the equivalence point of a titration.

(i) Write an equation for the reaction of ammonia with hydrochloric acid. *[1]*

(ii) Calculate the amount (in mol) of hydrochloric acid and ammonia that react. *[2]*

(iii) Calculate the mass of ammonia in the solution. *[2]*

(b) 0.100 mol dm^{-3} hydrochloric acid solution is added to 25.0 cm^3 0.100 mol dm^{-3} ammonia solution and the pH is recorded until a total of 35.0 cm^3 hydrochloric acid has been added.

(i) Sketch a graph to show how the pH changes as hydrochloric acid is added to the ammonia solution. Use a pH scale of 0 – 14, and an acid volume scale of 0 – 35 cm^3. Explain the shape of the curve. *[6]*

(ii) Use table 17 of the Data Booklet to suggest an indicator that could be used in the titration, explaining your choice. *[2]*

(c) (i) State the composition of an acidic buffer solution. *[1]*

(ii) Suggest the identity of an acid and its amount that could be added to a solution containing 0.10 mol ammonia in order to prepare a buffer. *[2]*

(iii) Explain how the solution you prepare in (c) (ii) can act as a buffer solution when a strong acid and a strong base are added to separate portions of it. Write an equation to illustrate the buffer action in **each** case. *[4]*

(iv) Write an equation for the reaction of ammonia with water, and write its K_b expression. *[2]*

(v) Given pK_b (ammonia) = 4.75, determine the pH when half the ammonia in a sample of cleaning solution has been neutralized. *[3]*