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FORM TP 2007172

MAY/JUNE 2007

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

CHEMISTRY

UNIT 1 – PAPER 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of SIX compulsory questions in TWO sections.
2. Section A consists of THREE structured questions, ONE from each Module. Section B consists of THREE extended response questions, ONE from each Module.
3. For Section A, write your answers in the spaces provided in this booklet. For Section B, write your answers in the separate answer booklet provided.
4. ALL working MUST be shown.
5. The use of non-programmable calculators is permitted.
6. A data booklet is provided.

SECTION A

Answer ALL questions in this section. Write your answer in the spaces provided in this booklet.

MODULE 1

FUNDAMENTALS IN CHEMISTRY

1. (a) Hess's law states that the total energy change in a reaction is independent of the route from reactants to products if the initial and final conditions of temperature and pressure are identical.

Given the following data:

$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$ $\quad \Delta H = -511.1$ kJ

$MgO(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2O(g)$ $\quad \Delta H = -151.1$ kJ

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ $\quad \Delta H = -483.6$ kJ

Use Hess's law to calculate the enthalpy change for the following reaction:

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$$

[3 marks]

(b) A student carries out an experiment to determine the enthalpy change of the reaction between magnesium and hydrochloric acid. She measures the steady temperature of 100 cm^3 of hydrochloric acid in a polystyrene cup. She then places a 10 cm long piece of magnesium, of mass 0.5971 g, in the acid and records the temperature every 30 seconds for 4 minutes, while stirring at regular intervals.

(i) Explain the reason for stirring the mixture at regular intervals.

[1 mark]

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(ii) Given that the initial and final temperatures are 28°C and 57°C respectively, sketch a typical graph for the results of the experiment to illustrate how the student arrived at the temperature change, ΔT, for the experiment.

[2 marks]

(iii) Give the main source of error for the experiment.

_____

_____

_____

[1 mark]

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(iv) Calculate the enthalpy change, in kJ mol^{-1} of Mg for the reaction at constant pressure, given

$\Delta T = 29.0^{\circ}C$

$C = 4.20\ Jg^{-1}\ ^{\circ}C^{-1}$.

The density of dilute HCl is $1.0g\ cm^{-3}$.

[3 marks]

(c) (i) Use the results of your calculation in (b) (iv) above to state whether the reaction is endothermic or exothermic.

[1 mark]

(ii) Draw a clearly labelled energy profile diagram for the reaction between magnesium and hydrochloric acid. Include on your diagram the enthalpy change for the reaction.

[4 marks]

Total 15 marks

MODULE 2

KINETICS AND EQUILIBRIA

2. (a) Methanoic acid, HCOOH, the irritant found in the sting of an ant, is a weak acid with an acid dissociation constant, K_a, of 1.6×10^{-4} mol dm^{-3}.

$$HCOOH(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCOO^-(aq)$$

(i) Explain what is meant by the term 'weak acid'.

_____

_____

[1 mark]

(ii) Write an expression for the dissociation constant, K_a, of methanoic acid.

[1 mark]

(b) A chemist extracts the methanoic acid from 40 ants and adds water to make 25.00 cm^3 of a Solution Y. He then titrates this solution with a 0.050 mol dm^{-3} standard solution of sodium hydroxide, NaOH(aq), a strong alkali, to determine the concentration of HCOOH in Solution Y.

(i) Using Bronsted-Lowry theory, explain what is meant by a strong base.

_____

_____

_____

_____

[2 marks]

(ii) Calculate the pH of the standard NaOH solution.

[2 marks]

(iii) The concentration of methanoic acid in Solution Y is found to be 6.0×10^{-3} mol dm^{-3}.

Calculate the pH of Solution Y.

[2 marks]

(iv) Suggest a suitable indicator for the titration between methanoic acid and sodium hydroxide.

_____

[1 mark]

(v) Sketch a graph to illustrate the changes in pH that take place during the titration.

[4 marks]

(c) Ant stings can be treated with baking soda, $NaHCO_3$. Suggest, with the aid of an equation, how baking soda helps to relieve the effect of the sting.

[2 marks]

Total 15 marks

MODULE 3

CHEMISTRY OF THE ELEMENTS

3. Barium is a member of the Group II elements in the periodic table. A barium sulphate meal is often fed to patients in preparation for X-ray analysis of the digestive tract.

(a) (i) Describe the reaction of barium metal with water. Include a balanced equation.

[4 marks]

(ii) Explain why the use of barium sulphate is acceptable in the X-ray analysis even though Ba^{2+} ions are toxic.

[2 marks]

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(b) Radium is a member of the Group II elements and is located at the bottom of the group. Predict EACH of the following:

(i) Thermal stability of $RaCO_3$ relative to the other Group II carbonates

_____

(ii) Ease of reaction between radium and oxygen

_____

[2 marks]

(c) Magnesium oxide is used in the walls of industrial furnaces. Suggest an explanation for this usage.

_____

_____

_____

[2 marks]

(d) A student heated two calcium salts, A and B, and the following results were obtained.

Compound A decomposed to give a gas which formed a white precipitate on being bubbled into an aqueous solution of calcium hydroxide.

Compound B decomposed to give two gases. One gas was brown in colour and turned moist blue litmus paper red and the other gas rekindled a glowing splint.

(i) Identify the gas evolved on heating Compound A.

_____

[1 mark]

(ii) Identify the TWO gases evolved on heating Compound B.

_____

[2 marks]

(iii) Deduce the molecular formulae of the two calcium salts.

Compound A: _____

Compound B: _____

[2 marks]

Total 15 marks

SECTION B

Answer ALL questions in this section. Write your answer in the answer booklet provided.

MODULE 1

FUNDAMENTALS IN CHEMISTRY

4. The safety air bags used in many vehicles are inflated on impact by a gas that is produced from the rapid decomposition of sodium azide, NaN_3.

(a) Assuming that the gas produced behaves as an ideal gas under these conditions:

(i) State TWO properties of an ideal gas. **[2 marks]**

(ii) Use the ideal gas equation to calculate the number of moles of gas produced in an air bag of volume 40.0 dm^3 at a pressure of 2.0 x 10^2 KPa and a temperature of 30°C. **[5 marks]**

(iii) Given that the mass of gas produced in the air bag is 90.0 g, use the answer from (a) (ii) to calculate the molar mass of the gas and suggest its identity. **[2 marks]**

(iv) Write the equation for the decomposition of NaN_3. **[2 marks]**

(b) (i) State the conditions of temperature and pressure under which gases deviate from ideality. **[2 marks]**

(ii) Describe the property of the gas molecules that is responsible for the deviation from ideality. **[2 marks]**

Total 15 marks

MODULE 2

KINETICS AND EQUILIBRIA

5. (a) State and explain the effect of EACH of the following on the rate of a chemical reaction:

(i) A catalyst **[2 marks]**

(ii) Concentration of the reactants **[3 marks]**

(b) Sulphur dichlorine oxide dissociates according to the following equation:

$$SO_2Cl_2(g) \rightarrow SO_2(g) + Cl_2(g)$$

The data in Table 1 was obtained from a kinetic study of the variation in the rate of dissociation of SO_2Cl_2 with concentration at a constant temperature.

TABLE 1

$[SO_2Cl_2]$ mol dm^{-3}	Rate of dissociation mol dm^{-3} s^{-1}
0.45	1.35×10^{-4}
0.39	1.17×10^{-4}
0.34	1.02×10^{-4}
0.28	8.40×10^{-5}
0.23	6.9×10^{-5}
0.18	5.4×10^{-5}

(i) Use the data given in Table 1 to calculate the order of the reaction with respect to the SO_2Cl_2. **[2 marks]**

(ii) Write the rate equation for the reaction and calculate the value and units for the rate constant. **[4 marks]**

(iii) Calculate $t_{1/2}$ for the reaction. **[2 marks]**

(iv) State and explain the effect on the rate of dissociation of SO_2Cl_2, of carrying out the experiment at a higher temperature. **[2 marks]**

Total 15 marks

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MODULE 3

CHEMISTRY OF THE ELEMENTS

6. The reaction shown in Figure 1 illustrates the reaction occurring between oxyhaemoglobin and carbon monoxide to form carboxyhaemoglobin.

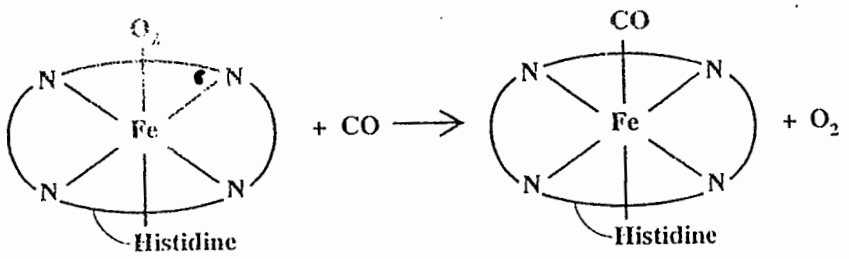

Figure 1

(a) (i) Define the term 'ligand' and identify two ligands in the haemoglobin structures in Figure 1. **[4 marks]**

(ii) State and explain the principle on which the reaction in Figure 1 is based. **[2 marks]**

(b) Carbon monoxide, CO, formed from the incomplete combustion of fossil fuels, poses no threat to vegetation but is extremely toxic to humans at high concentrations.

(i) Using the information in Figure 1, account for the toxic effect of carbon monoxide at high concentrations. **[3 marks]**

(ii) Suggest a treatment for a patient suffering from overexposure to carbon monoxide and give a reason for your suggestion. **[2 marks]**

(c) Account for the origin of colour in transition metal complexes. **[4 marks]**

Total 15 marks

END OF TEST