Chemistry II

013

04 Nov. 2011 08.30am - 11.30am

REPUBLIC OF RWANDA

RWANDA EDUCATION BOARD (REB)
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ADVANCED LEVEL NATIONAL EXAMINATIONS 2011

SUBJECT: CHEMISTRY II

PAPER II: THEORY

COMBINATIONS: - BIOLOGY-CHEMISTRY-GEOGRAPHY: BCG
- MATHEMATICS-CHEMISTRY-BIOLOGY: MCB
- PHYSICS-CHEMISTRY-BIOLOGY: PCB
- PHYSICS-CHEMISTRY-MATHEMATICS: PCM

DURATION: 3 HOURS

INSTRUCTIONS:

This paper consists of **two** sections: **A** and **B**.

Section A: Attempt **all** questions. **(70 marks)**

Section B: Attempt any **three** questions. **(30 marks)**

You do not need the Periodic Table.

Silent non-programmable calculators may be used.

SECTION A : Attempt all questions. ***(70 marks)***

01. (a) Give the systematic names of three alcohols whose molecular formula is C_4H_9OH. ***(3 marks)***

(b) One of the alcohols in (a) can be oxidized to form a ketone.

(i) Give the structural formula of the alcohol. ***(1 mark)***

(ii) Give the structural formula of the ketone. ***(1 mark)***

02. 14.8g of magnesium nitrate were heated until there was no further change in the mass.

(a) Write a balanced equation for the reaction. ***(2 marks)***

(b) Calculate the mass of magnesium oxide produced. ***(2 marks)***

03. The atomic number of arsenic (As) is 33.

(a) Using s, p, d notation, give the electronic configuration of arsenic. ***(1 mark)***

(b) Predict the molecular formulae of two chlorides of arsenic. ***(2 marks)***

(c) Deduce the molecular shape and the bond angle of the chloride of arsenic in which arsenic shows a lower oxidation number. ***(2 marks)***

04. Aqueous bromide ions are oxidized by hydrogen peroxide in acidic medium according to the equation below:

$2Br^-_{(aq)} + H_2O_{2(aq)} + 2H^+_{(aq)} \rightleftharpoons Br_{2(aq)} + 2H_2O_{(l)}$ ΔH = negative

Predict and explain the effect on the equilibrium position when:

(a) A small amount of aqueous potassium bromide is added. ***(2 marks)***

(b) A small amount of aqueous sodium hydroxide is added. ***(2 marks)***

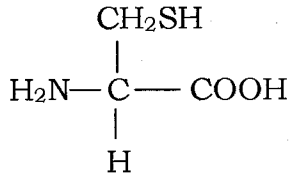
(c) The temperature is increased. ***(2 marks)***

05. (a) What is meant by the term 'electronegativity'? ***(2 marks)***

(b) State and explain the trend in electronegativity across period 3 from Na to Cl. ***(2 marks)***

(c) Explain the trend in polarity of the molecules of Group 7 hydrides from HF to HI. ***(2 marks)***

06. A naturally occurring amino acid cystine has the structure given below:



(a) Give the structural formula of a tripeptide formed from cystine molecules. ***(2 marks)***

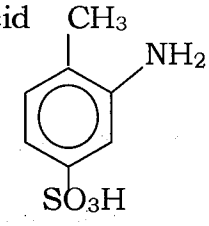
(b) Give the structural formula of the zwitterion formed from cystine. ***(1 mark)***

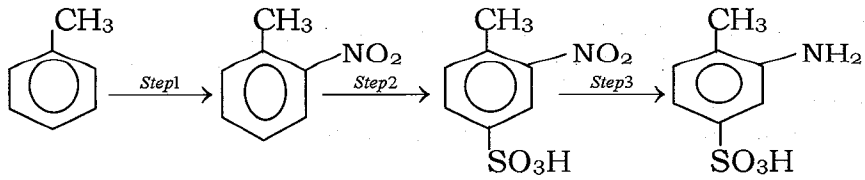
(c) Give the structural formula of the organic product formed when cystine reacts with:

(i) Hydrochloric acid solution. ***(1 mark)***

(ii) Aqueous sodium carbonate. ***(1 mark)***

(iii) Ethanol in the presence of an acid catalyst. ***(1 mark)***

07. A sulphonic acid  can be synthesized from methylbenzene according to the scheme shown below.

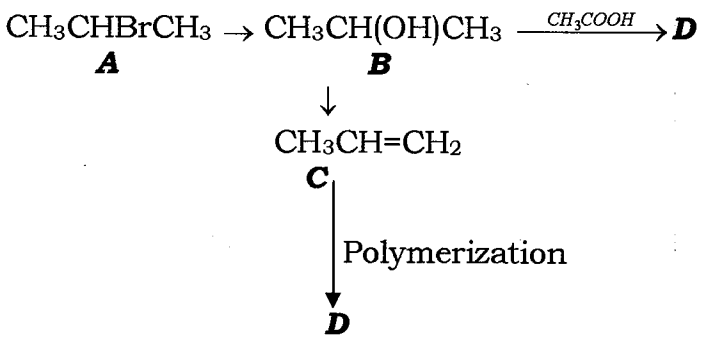


(a) What type of reaction is step 2? ***(1 mark)***

(b) For each of the steps 1 to 3, state the reagents and conditions needed to carry out the reaction. ***(6 marks)***

(c) Outline the mechanism for the reaction in step 2. ***(3 marks)***

08. The scheme below shows a number of reactions starting with 2-bromopropane (***A***).



(a) State the reagent and the type of reaction for converting ***A*** into ***B***. ***(2 marks)***

(b) Give the structural formula of compound ***D***. ***(1 mark)***

(c) Give the reagent and condition for converting ***B*** into ***C***. ***(2 marks)***

(d) Outline the mechanism for the reaction in which ***A*** is converted into ***B***. ***(3 marks)***

09. (a) What is meant by a Bronsted-Lowry acid?
Give one equation to show that ethanoic acid is a Bronsted-Lowry acid. ***(2 marks)***

(b) A buffer solution contains ethanoic acid and sodium ethanoate.
Using equations, explain how this buffer solution resists a change in pH when small amounts of acid or base are added. ***(4 marks)***

(c) Calculate the pH of a buffer solution which consists of 0.200 mol dm^{-3} of ethanoic acid and 0.250 mol dm^{-3} of sodium ethanoate. ***(3 marks)***
(K_a of ethanoic acid = 1.75×10^{-3} mol dm^{-3}).

10. The melting points of oxides of period 3 of the Periodic Table are given in the table below:

Oxide	Na_2O	MgO	Al_2O_3	SiO_2	P_4O_{10}	SO_3
M.P.(°C)	1275	2827	2017	1607	580	33

Explain the following observations in terms of structure and bonding of the relevant oxides:

(a) The melting point of MgO is greater than that of SO_3. ***(2 marks)***

(b) The melting point of SiO_2 is greater than that of P_4O_{10}. ***(2 marks)***

11. Describe all colour changes that are observed when aqueous ammonia is gradually added to a solution of $Cu^{2+}_{(aq)}$.
Write a balanced equation for one of the reactions that occurs. ***(3 marks)***

12. For the elements of period 3 (Na to Ar) of the Periodic Table, state and explain:

(a) The general trend in the first ionization energy. ***(2 marks)***

(b) Why the first ionization energy of sulphur is lower than that of phosphorus. ***(2 marks)***

(Atomic Numbers: P = 15; S = 16)

SECTION B: Attempt any three questions. ***(30 marks)***

13. 7.00g of an impure sample of tin were reacted with dilute hydrochloric acid to convert it to tin (II) (Sn^{2+}) ions in aqueous solution. The solution was made up to 1 dm^3 with distilled water. 25.0 cm^3 of this solution were titrated with 0.02 mol dm^{-3} of acidified potassium manganate (VII) solution. 24.0 cm^3 of the manganate (VII) solution were needed to react completely with 25.0 cm^3 of the $Sn^{2+}_{(aq)}$. The relevant half-equations are:

$$Sn^{2+} \rightarrow Sn^{4+} + 2e^-$$
$$MnO_4^- + 5e^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O$$

(a) Write a balanced redox equation for the reaction between Sn^{2+} and acidified MnO_4^-. ***(2 marks)***

(b) Calculate the change in oxidation number of manganese in the redox reaction. ***(1 mark)***

(c) Calculate the number of moles of MnO_4^- in 24.0 cm^3 of the solution. ***(1 mark)***

(d) Calculate the number of moles of Sn^{2+} in 25.0 cm^3 of the solution and hence the concentration of Sn^{2+} in mol dm^{-3}. ***(2 marks)***

(e) Calculate the percentage of Sn in the original sample of tin. [A_r(Sn) = 119] ***(2 marks)***

(f) Using examples of CO_2 and SnO_2, briefly explain the trend in the acid-base character of oxides of Group IV in oxidation state +4. ***(2 marks)***

14. The production of ammonia in the Haber process involves the reaction:

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

(a) Write an expression for the equilibrium constant, K_c, for the above reaction. ***(1 mark)***

(b) 0.20 mol of $N_{2(g)}$ and 0.20 mol of $H_{2(g)}$ were reacted in a 1 dm^3 closed container until equilibrium was reached. At equilibrium, the concentration of $NH_{3(g)}$ was 0.060 mol dm^{-3}.

(i) Calculate concentrations of $N_{2(g)}$ and $H_{2(g)}$ at equilibrium. ***(2 marks)***

(ii) Calculate the value of K_c and state its units. ***(2 marks)***

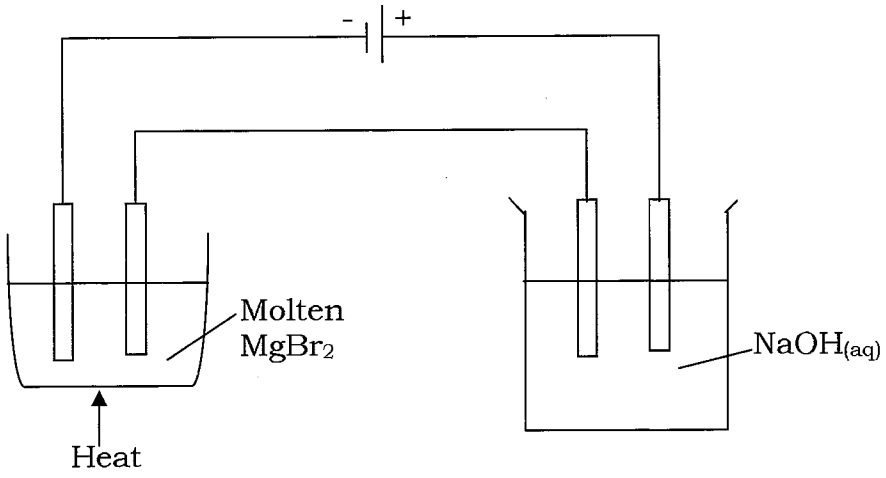
(c) How does an increase in pressure affect the yield of ammonia? Explain your answer. ***(2 marks)***

(d) The actual conditions used in the Haber process are a temperature of 500°C and a pressure of 200 atmospheres. Why are these conditions used instead of the conditions that would give the highest yield? ***(2 marks)***

(e) Give one large scale use of ammonia. ***(1 mark)***

15. (a) With the help of equations of reactions which occur at each electrode, outline what happens during electrolysis of dilute aqueous sodium chloride. What happens to the pH of the solution as electrolysis continues? ***(3 marks)***

(b) Two electrolytic cells containing molten magnesium bromide and dilute sodium hydroxide respectively are connected in series as shown in the diagram below.



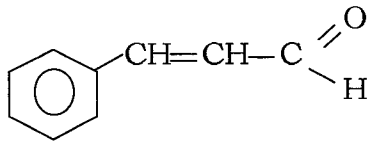
The electrodes in both cells are inert. 6.0 g of magnesium is produced in the first cell.

(i) Identify the products produced in the second cell. ***(2 marks)***

(ii) Calculate the mass of each product in the second cell. ***(3 marks)***
(Mg = 24, Br = 80, Na = 23, H = 1, O = 16)

(c) Briefly outline a method of purifying copper using electrolysis. ***(2 marks)***

16. (a) The organic compound whose structure is shown below can be extracted from some plants:



Give the structural formula of the organic compound formed when the above compound reacts with

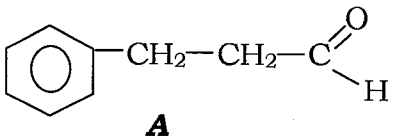
(i) Steam ***(1 mark)***

(ii) Hydrogen cyanide ***(1 mark)***

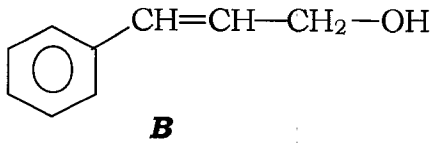
(iii) Acidified $K_2Cr_2O_7$ ***(1 mark)***

(iv) Bromine water or bromine dissolved in an organic solvent. ***(1 mark)***

(b) Describe simple test tube reactions you could use to distinguish between two compounds ***A*** and ***B*** shown below:



A



B

In each test, state the reagents and what you would observe. You need to describe one test in each case. ***(4 marks)***

(c) State two different methods used to produce ethanol on a large scale in industries. ***(2 marks)***

17. (a) By means of equations, outline the steps involved in the manufacture of sulphuric acid from sulphur in the contact process. ***(4 marks)***

(b) Concentrated sulphuric acid can be used to prepare hydrogen chloride from sodium chloride. Briefly explain why a similar method is not suitable for preparing hydrogen bromide from sodium bromide. ***(2 marks)***

(c) Briefly explain why water is a liquid which boils at 100°C at normal atmospheric pressure while hydrogen sulphide is a gas at room temperature and pressure. ***(2 marks)***

(d) Briefly explain the environmental impact of using coal containing sulphur as a source of energy. ***(2 marks)***