

**Chemistry II**

**014**

**16 Nov. 2012 08.30am - 11.30am**

**REPUBLIC OF RWANDA**



**RWANDA EDUCATION BOARD (REB)**

**ADVANCED LEVEL NATIONAL EXAMINATIONS 2012**

**SUBJECT: CHEMISTRY**

**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)**

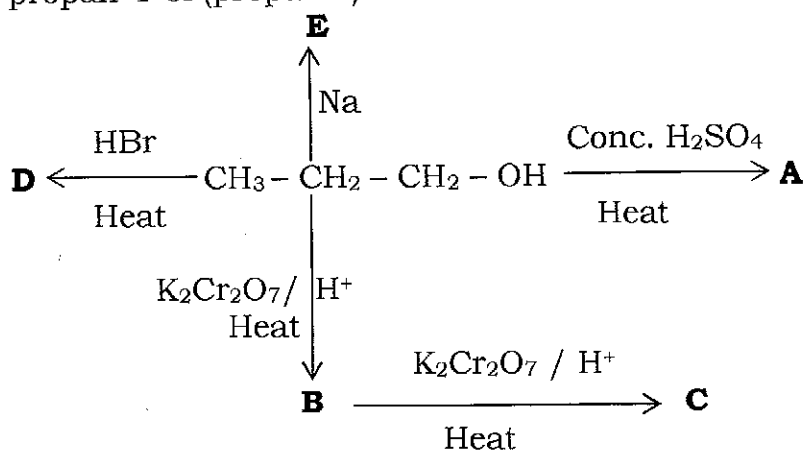
**You do not need the Periodic Table.**

Silent non-programmable calculators may be used.

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

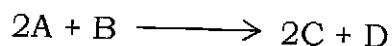
01. The molecular formula  $C_3H_6O$  represents two isomers. (1 mark)
- (a) Define the term "isomers". (1 mark)
- (b) Give the structural formulae of the two isomers and name them. (4 marks)
- (c) Give a chemical test that could be used to distinguish between the two isomers, clearly stating the expected observations. (2 marks)
02. Manganese (atomic number 25) is a transition element. It forms several compounds in which it shows different oxidation state.
- (a) Give the electronic configuration of manganese (Mn) using the s, p, d ... notation. (1 mark)
- (b) Give the formula of an ion or compound in which the oxidation state/number of manganese is +7. (1 mark)
- (c) Manganese (IV) oxide is used to prepare chlorine gas according to the reaction below:
- $$MnO_2(s) + 4HCl(conc.) \xrightarrow{heat} MnCl_2(aq) + Cl_2(g) + H_2O(l)$$
- (i) Which element/ion is reduced and which one is oxidised? (2 marks)
- (ii) How could you show by a chemical test that chlorine gas is evolved? (1 mark)
03. Silicon exists as three isotopes whose abundance is shown below:
- 92% as  $^{28}_{14}Si$ , 5% as  $^{29}_{14}Si$  and 3% as  $^{30}_{14}Si$ .
- (a) Explain what is meant by the term "isotopes". (1 mark)
- (b) Calculate the relative atomic mass of silicon. (2 marks)
- (c) Silicon dioxide (silicon (IV) oxide) is a solid of high melting point. Explain in terms of bonding and structure why silicon dioxide has a high melting point. (1 mark)

04. The reaction scheme below shows some reactions of propan-1-ol (propanol).



- (a) Give the formulae or the names of the organic compounds **A**, **B**, **C**, **D** and **E**. (5 marks)
- (b) Why do alcohols have high boiling points compared to alkanes? (2 marks)
05. The standard enthalpy change of formation of ethanol may be calculated by enthalpies of combustion of ethanol, carbon and hydrogen. The enthalpies of combustion are given below:
- $$\Delta H_c^\theta (\text{C}_2\text{H}_5\text{OH}) = -1368 \text{ kJmol}^{-1}$$
- $$\Delta H_c^\theta (\text{H}_2) = -286 \text{ kJmol}^{-1}$$
- $$\Delta H_c^\theta (\text{C}) = -394 \text{ kJmol}^{-1}$$
- (a) Define "standard enthalpy change of formation". (2 marks)
- (b) Use the above data to calculate the standard enthalpy change of formation of ethanol. (3 marks)
06. The conversion of sulphur dioxide into sulphur trioxide in the contact process is a reversible reaction.
- (a) Write a balanced equation for the reaction. (2 marks)
- (b) Write an expression for the equilibrium constant,  $K_c$ , for the reaction in (a). (1 mark)
- (c) Calculate the value of the equilibrium constant,  $K_c$ , and state its units given that the amounts present at equilibrium were: (3 marks)
- $$\text{SO}_2 = 0.4 \text{ mol dm}^{-3}; \text{O}_2 = 0.2 \text{ mol dm}^{-3}; \text{SO}_3 = 1.2 \text{ mol dm}^{-3}.$$

07. A reaction between A and B is represented by the equation:

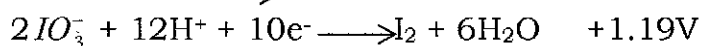
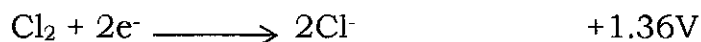


The reaction is known to be a second order with respect to A and first order with respect to B.

- Write a rate expression or rate equation for the above reaction. (1 mark)
  - State the overall order of the reaction. (1 mark)
  - Deduce the units of the rate constant. (1 mark)
  - If the concentration of both A and B are doubled by what factor does the rate change? (1 mark)
08. The table below shows the boiling points of chlorides of period 3 in the Periodic Table.

Chloride	NaCl	MgCl <sub>2</sub>	Al <sub>2</sub> Cl <sub>6</sub>	SiCl <sub>4</sub>	PCl <sub>3</sub>	S <sub>2</sub> Cl <sub>2</sub>
Boiling point (°C)	1465	1418	423	57	74	136

- Explain why the boiling points of MgCl<sub>2</sub> and PCl<sub>3</sub> are so different. (2 marks)
  - Explain the bonding present in Al<sub>2</sub>Cl<sub>6</sub>. (2 marks)
09. The table below shows standard electrode potentials of some ions of group 7 elements of the Periodic Table.

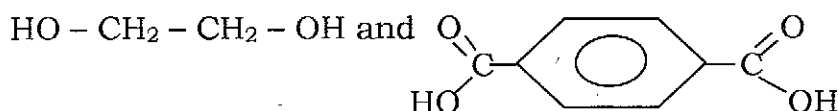


- Calculate the oxidation number of I in IO<sub>3</sub><sup>-</sup>. (1 mark)
  - Write a balanced ionic equation for the reaction between IO<sub>3</sub><sup>-</sup> and I<sup>-</sup> in the presence of an acid. (3 marks)
- Calculate the standard cell e.m.f (E<sup>0</sup> cell) for the reaction.
- Would you expect a reaction between I<sub>2</sub> and Cl<sup>-</sup>? Give a reason for your answer. (2 marks)
10. Ammonia reacts with water as shown by the equation below:
- $$\text{NH}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$$
- Identify the acid-base conjugate pairs in the reaction. (2 marks)
  - The base dissociation constant (K<sub>b</sub>) for ammonia is 1.20 × 10<sup>-5</sup> mol dm<sup>-3</sup>.
    - Write an expression for K<sub>b</sub> of ammonia. (1 mark)

- (ii) Calculate the concentration of  $\text{OH}^-$  ions in  $0.1 \text{ mol dm}^{-3}$   $\text{NH}_3(\text{aq})$  and hence the pH of ammonia solution.  
 ( $K_w = 1.0 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$  at  $25^\circ\text{C}$ )

**(3 marks)**

11. Terylene is a polymer made from ethane-1,2-diol and benzene-1,4-dicarboxylic acid. The monomers are:



- (a) Give the structure of terylene showing only one repeat unit.

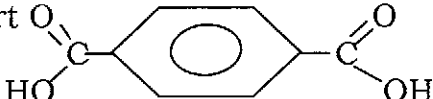
**(1 mark)**

- (b) What type of polymer is terylene?

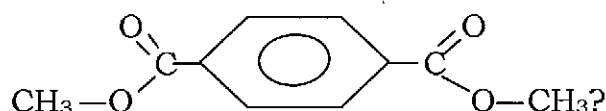
**(1 mark)**

- (c) Give one advantage of terylene compared to poly(ethene).

**(1 mark)**

- (d) How would you convert 

into



**(2 marks)**

State the reagent and conditions.

12. The half-life of cobalt-60 ( $^{60}_{27}\text{Co}$ ) is 5.2 years.

- (a) What fraction of cobalt-60 would remain after 26 years?

**(2 marks)**

- (b) State one medical use of cobalt-60.

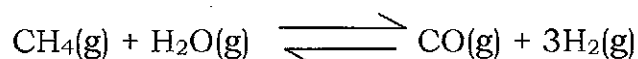
**(1 mark)**

- (c) One of the complex ions of cobalt is  $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$ .

Give the oxidation number of cobalt and the name of the shape of this complex ion.

**(2 marks)**

13. Hydrogen gas can be manufactured by reacting methane gas with steam under suitable conditions as shown by the equation:



The forward reaction is endothermic.

State and explain the effect on the position of equilibrium when

- (a) Pressure is increased.

**(2 marks)**

- (b) Temperature is increased.

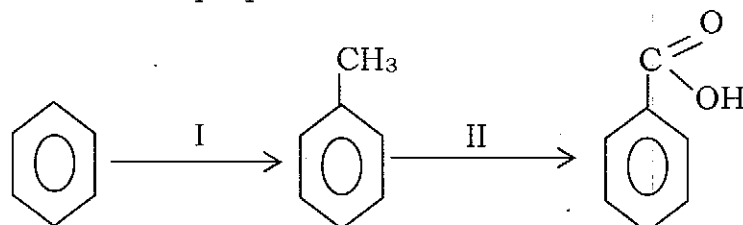
**(2 marks)**

- (c) More carbon monoxide is added.

**(2 marks)**

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

14. Benzoic acid is prepared from benzene as shown below:

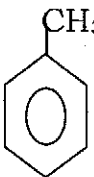


(a) Give the reagents and conditions for step I.

**(2 marks)**

(b) Give the reagent and conditions for step II.

**(2 marks)**

(c) Methylbenzene, , reacts with chlorine under

conditions to give different products.

(i) Give the structure of the organic product when methylbenzene and chlorine react in the presence of UV light **(1 mark)**

(ii) Give the structure of two isomers formed when methylbenzene reacts with chlorine in the presence of  $\text{FeCl}_3$ . **(2 marks)**

(d) Benzoic acid is a weak acid.

(i) What is meant by "a weak acid"?

**(1 mark)**

(ii) The acid dissociation constant of benzoic acid ( $K_a$ ) is  $6.4 \times 10^{-5} \text{ mol dm}^{-3}$ .

Calculate the pH of  $0.1 \text{ mol dm}^{-3}$  benzoic acid solution.

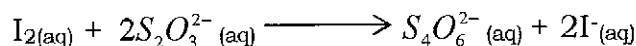
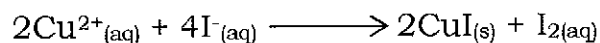
(You may use a simpler formula of benzoic acid as

$\text{C}_6\text{H}_5\text{COOH}$ .)

**(2 marks)**

15. An alloy of copper was converted into copper (II) ions using a suitable reagent. 4.0g of the alloy was converted into  $400 \text{ cm}^3$  of a solution of  $\text{Cu}^{2+}$  ions.  $40 \text{ cm}^3$  of the  $\text{Cu}^{2+}(\text{aq})$  was reacted with potassium iodide solution to produce iodine solution. The iodine solution reacted completely with  $50.0 \text{ cm}^3$  of  $0.1 \text{ mol dm}^{-3}$  sodium thiosulphate ( $\text{Na}_2\text{S}_2\text{O}_3$ ) solution. The

following ionic equations represent the main reactions which occurred:



(thiosulphate ions)

- (a) Calculate the number of moles of  $\text{S}_2\text{O}_3^{2-}$  present in  $50\text{cm}^3$  of  $0.1\text{mol dm}^{-3} \text{Na}_2\text{S}_2\text{O}_3$ . (1 mark)
  - (b) Calculate the number of moles of iodine that reacted with  $\text{S}_2\text{O}_3^{2-}$  ions. (1 mark)
  - (c) Calculate the number of moles  $\text{Cu}^{2+}$  in  $40\text{cm}^3$  of solution of  $\text{Cu}^{2+}$ . (1 mark)
  - (d) Calculate the number of moles of  $\text{Cu}^{2+}$  in  $400\text{cm}^3$  of solution. (1 mark)
  - (e) Calculate the mass of copper and hence the percentage of Cu in the alloy ( $\text{Cu} = 63.5$ ). (3 marks)
  - (f) A sample of  $\text{Cu}^{2+}_{(\text{aq})}$  is reacted with aqueous ammonia until ammonia is in excess. State what would be observed and give the formula of the copper species present. (2 marks)
  - (g) Calculate the oxidation number of S in  $\text{S}_2\text{O}_3^{2-}$ . (1 mark)
16. Electrolysis of brine (concentrated sodium chloride solution) is used to manufacture three different products.
- (a) Using equations, explain the formation of the three products, showing clearly what happens at each electrode. (3 marks)
  - (b) During electrolysis of brine, a current of  $0.5\text{A}$  was passed for two and half hours.
    - (i) Calculate the quantity of electricity (amount of charge) passed. (2 marks)
    - (ii) Calculate the mass of the product at the anode. (2 marks)

( $\text{H} = 1$ ,  $\text{Cl} = 35.5$ ,  $\text{Na} = 23$ ,  $\text{O} = 16$ ,  $1\text{Faraday} = 96\,500\text{C}$ .)

- (iii) Calculate the mass of the product at the cathode. **(2 marks)**
- (c) What happens to the pH of the solution as electrolysis continues? Give a reason. **(1 mark)**
17. Describe a chemical test you would use to distinguish between the pairs of compounds below. In each case give the reagent, conditions and the expected observation.
- (a)  $\text{CH}_3 - \text{CH}_2 - \text{CH}_3$  and  $\text{CH}_3\text{CH} = \text{CH}_2$  **(2 marks)**
- (b)  $\text{CH}_3 - \text{CH}_2 - \underset{\text{OH}}{\text{CH}} - \text{CH}_3$  and  $\text{CH}_3 - \overset{\text{CH}_3}{\underset{\text{CH}_3}{\text{C}}} - \text{OH}$  **(2 marks)**
- (c)  $\text{CH}_3 - \overset{\text{O}}{\parallel}{\text{C}} - \text{O} - \text{CH}_3$  and  $\text{CH}_3 - \text{CH}_2 - \text{COOH}$  **(2 marks)**
- (d)  $\text{FeSO}_4$  and  $\text{CuSO}_4$  **(2 marks)**
- (e)  $\text{CH}_3 - \text{CH}_2 - \overset{\text{O}}{\parallel}{\text{C}} - \text{Cl}$  and  $\text{CH}_3 - \text{CH}_2 - \text{CH}_2\text{Cl}$  **(2 marks)**
18. The chloride and oxide of phosphorus in the higher oxidation state are:  $\text{PCl}_5$  and  $\text{P}_2\text{O}_5$ .
- (a) Give the formulae of the chloride and oxide of phosphorus in a lower oxidation state. **(2 marks)**
- (b) Write a balanced equation for the reaction of  $\text{PCl}_5$  with water. **(2 marks)**
- (c) Write a balanced equation for the reaction of  $\text{P}_2\text{O}_5$  with water. **(2 marks)**
- (d)  $25\text{cm}^3$  of the resulting solution of the reaction between  $\text{P}_2\text{O}_5$  and water reacted completely with  $25\text{cm}^3$  of  $0.6\text{mol dm}^{-3}$   $\text{NaOH}$ . **(2 marks)**  
Calculate the concentration of the solution.
- (e) What is the name of the shape of  $\text{PCl}_5$ ? Give one of the bond angles in that shape. **(2 marks)**