

**CHEMISTRY II**

**014**

15/11/ 2019 8:30 AM – 11:30 AM



**Rwanda Education Board**

**ADVANCED LEVEL NATIONAL EXAMINATIONS, 2019**

**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:**

- 1) Write your names and index number on the answer booklet as written on your registration form and **DO NOT** write your names and index number on additional answer sheets of paper if provided.
- 2) Do not open this question paper until you are told to do so.
- 3) This paper consists of two sections: **A** and **B**.  
**SECTION A:** Attempt **ALL** questions. (70 marks)  
**SECTION B:** Attempt any **THREE** questions. (30 marks)
- 4) You are not allowed to use the periodic table.
- 5) Silent non-programmable calculators may be used.
- 6) Use only a **blue** or **black** pen for answering and a **pencil** for drawing.

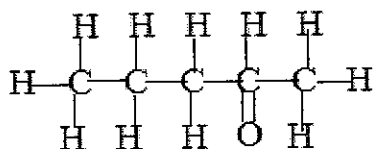
## SECTION A: Attempt all questions (70 marks)

- 1) a) Describe what takes place in the ionization chamber of a mass spectrometer so that positive ions of a sample can be produced. (2 marks)
- b) The percentage abundance of chromium isotopes  $^{50}\text{Cr}$ ,  $^{52}\text{Cr}$ ,  $^{53}\text{Cr}$  and  $^{54}\text{Cr}$  are 4.345 %, 83.789 %, 9.501 % and 2.365 % respectively.
- i) Calculate the relative atomic mass of chromium. (2 marks)
- ii) Describe 2 useful applications of isotopes by man. (2 marks)
- 2) Draw diagrams of the shapes of the following molecules and in each case state the name of the shape.
- a)  $\text{CO}_2$  (1.5 marks)
- b)  $\text{BCl}_3$  (1.5 marks)
- (Atomic number: B=5, Cl=17, C=6, O=8)
- 3) a) Describe 2 similarities in terms of chemical properties between beryllium and aluminium elements. (2 marks)
- (Beryllium is in group 12 and aluminium is in group 13 of the periodic table)
- b) Explain why  $\text{PbBr}_4$  and  $\text{PbI}_4$  do not exist whereas  $\text{PbCl}_4$  exists. (2 marks)
- c) Evaluate the social-economic importance of aluminium and boron compounds to the Rwandan society. (2 marks)
- 4) a) Write the equation of the reaction between concentrated  $\text{H}_2\text{SO}_4$  and HI. (1 mark)
- b) Explain why HF has a higher boiling point than HCl, HBr and HI despite its lower molecular mass than the rest. (2 marks)
- c) Evaluate the important uses and hazards of chlorine compounds. (2 marks)
- 5) During the reaction of formation of  $\text{Al}_2\text{O}_3$  from 5.4 g of Al and enough of  $\text{O}_2$ , the temperature liberated increased the temperature of 2 Kg of water by  $20^\circ\text{C}$ .  
Find the value of the standard enthalpy of formation of  $\text{Al}_2\text{O}_3$ . (3 marks)
- (Atomic mass: Al=27, specific heat capacity of water =  $4.2 \text{ J/g } ^\circ\text{C}$ )
- 6) Petrol is composed of isomers of  $\text{C}_8\text{H}_{18}$ .
- a) Write the structural formula of 2,3,3-Trimethyl pentane. (1 mark)

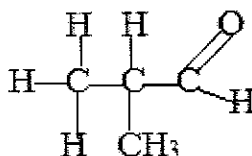
b) Give one reason to explain why 2,3,3-Trimethyl pentane is a better fuel component in vehicle engines than n-octane. **(1 mark)**

c) Explain the reason why unleaded petrol is recommended for use in vehicles in most parts of the world than leaded petrol. **(2 marks)**

7) a) Study the structural formula of the following organic compounds and answer the questions that follow:



Compound X

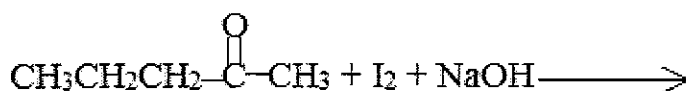


Compound Y

i) Write the IUPAC name of compound X and of compound Y shown above. **(2marks)**

ii) Suggest a chemical test reagent that can be used to distinguish between the organic substance X and Y shown above and mention the observable change in each case. **(2marks)**

b) Complete the chemical equation given below by writing the semi-developed formulae of all organic products and molecular formulae of inorganic products. **(2marks)**

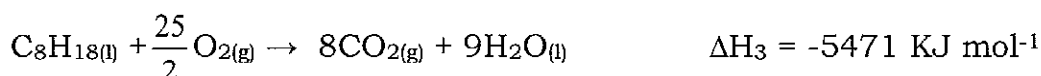


8) Balance the following reduction-oxidation chemical reaction equations.

a)  $\text{Fe}^{2+}(\text{aq}) + \text{H}^+(\text{aq}) + \text{Cr}_2\text{O}_7^{2-}(\text{aq}) \rightarrow \text{Cr}^{3+}(\text{aq}) + \text{Fe}^{3+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$  **(2 marks)**

b)  $\text{I}_2(\text{aq}) + \text{NO}_3^-(\text{aq}) + \text{H}^+(\text{aq}) \rightarrow \text{NO}_2(\text{g}) + \text{IO}_3^-(\text{aq}) + \text{H}_2\text{O}(\text{l})$  **(2 marks)**

9) Use the data given below to calculate the standard enthalpy of formation  $\Delta H_f$  of octane,  $\text{C}_8\text{H}_{18}(\text{l})$ : **(4 marks)**



10) The dissociation constant ( $K_b$ ) of a 0.2 mole/litre solution of methyl amine is  $4.4 \times 10^{-4}$ . Calculate:

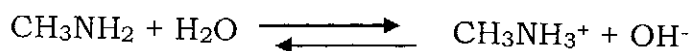
a) The number of moles of  $\text{OH}^-$  in 1 litre of the methyl amine solution.

**(2 marks)**

b) The pH of the 0.2 mole/litre solution of methyl amine.

**(3 marks)**

Equation:



*(Methyl amine is a weak base)*

11) Using appropriate steps with equations of reactions, show how you can synthesize  $\text{CH}_3\text{CH}_2\text{NH}_2$  from  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$

**(4 marks)**

12) The solubility product ( $K_{sp}$ ) of silver chromate,  $\text{Ag}_2\text{CrO}_4$  in water is  $3 \times 10^{-12}$



a) Calculate the solubility in  $\text{g dm}^{-3}$  of silver chromate VI ( $\text{Ag}_2\text{CrO}_4$ ) in water.

**(2 marks)**

b) Calculate the solubility in mole/litre of  $\text{Ag}_2\text{CrO}_4$  in 1 litre of a solution of 0.02 mole/litre  $\text{Na}_2\text{CrO}_4$ .

**(2 marks)**

*(0.02 mole/litre  $\text{Na}_2\text{CrO}_4$  solution dissolves completely in water)*  
*(Atomic mass, Ag=107, Cr=52, O=16).*

c) Discuss 2 important applications of solubility in the Rwandan society.

**(2 marks)**

13) a) Write the structural formula of 2-bromo-4-methyl pentane.

**(1 mark)**

b) Write the equation for the reaction of nucleophilic substitution between 2-bromo-4-methyl pentane and aqueous sodium hydroxide,  $\text{NaOH}$ .

*(use semi-developed formulae)*

**(2 marks)**

c) 2-bromo-4-methyl pentane is made to react with sodium cyanide,  $\text{NaCN}$  to form organic product A.

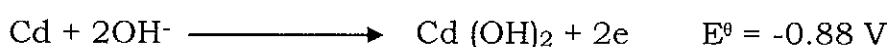
The resultant organic product A is reacted with  $\text{LiAlH}_4$  in the presence of  $\text{H}_2\text{O}$  to give organic product B.

Give the IUPAC name or the structural formula of compounds A and B.

**(2 marks)**

14) Nickel-Cadmium cells are used to power electrical equipments such as drills and shavers.

The electrode reaction equations are given below:



- a) Calculate the standard e.m.f of a Nickel-Cadmium cell. (1.5 marks)
- b) Deduce the overall equation for the reactions that occur in the cell when it is used. (1.5 marks)
- c) Describe the difference between rechargeable cells such as those used in mobile telephones and the non-rechargeable cells. (2 marks)
- 15) a) Describe the term “thermosoftening polymer” and indicate an example of such a polymer. (2 marks)
- b) Explain how tyres used in vehicles and bicycles are made hard during the process of polymerization (synthesis) in industry. (2 marks)

### SECTION B : Attempt THREE questions (30 marks)

- 16) a) Glass is essentially made of silicon and boron compounds.  
 (i) Explain the reason why glass is not used to make containers of NaOH solution (use chemical equations to support your answer). (2 marks)
- (ii) State 2 similarities between silicon and boron. (2 marks)
- b) Tin, SnO<sub>2</sub> is mined in some parts of Rwanda.  
 (i) Write the equation of the reaction between SnO<sub>2</sub> and hot concentrated H<sub>2</sub>SO<sub>4</sub>. (2 marks)
- (ii) Write the equation of the reaction between SnO<sub>2</sub> and NaOH. (2 marks)
- (iii) Describe the important applications of tin on a large scale. (2 marks)
- 17) Organic acid X has the formula (CH<sub>2</sub>)<sub>n</sub>(COOH)<sub>2</sub> and reacts with dilute sodium hydroxide, NaOH according to the following equation:  

$$(CH_2)_n(COOH)_2 + 2NaOH \longrightarrow (CH_2)_n(COONa)_2 + 2H_2O$$
- The mass of 2.0 g of organic acid X is dissolved in water and the solution made up to 250 cm<sup>3</sup>.  
 This organic acid X solution is filled in a burette and 18.40 cm<sup>3</sup> of (CH<sub>2</sub>)<sub>n</sub>(COOH)<sub>2</sub> is required to neutralize 25 cm<sup>3</sup> of a 0.1 mol dm<sup>-3</sup> NaOH.
- a) Calculate the number of moles of NaOH in 25 cm<sup>3</sup> solution. (2 marks)
- b) Determine the number of moles of (CH<sub>2</sub>)<sub>n</sub>(COOH)<sub>2</sub> that reacted with 25 cm<sup>3</sup> of the 0.1 mol dm<sup>-3</sup> NaOH solution. (1 mark)

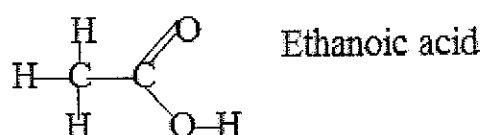
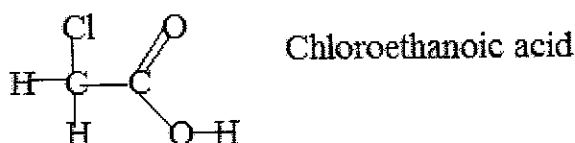
- c) Calculate the number of moles of  $(\text{CH}_2)_n(\text{COOH})_2$  present in  $250 \text{ cm}^3$  solution. (2 marks)
- d) Deduce the molecular mass of  $(\text{CH}_2)_n(\text{COOH})_2$  acid. (3 marks)
- e) Find the value of  $n$ . (2 marks)  
*(Atomic mass: C=12, H=1 and O=16)*

18) Study the data of the enthalpy changes in the table below and answer the questions that follow:

Equations of reactions	Enthalpy change / $\text{KJ mol}^{-1}$
$\text{AgI}_{(\text{s})} \rightarrow \text{Ag}^+_{(\text{aq})} + \text{I}^-_{(\text{aq})}$	$\Delta H_2 = +112$
$\text{Ag}^+_{(\text{g})} \rightarrow \text{Ag}^+_{(\text{aq})}$	$\Delta H_3 = -464$
$\text{I}^-_{(\text{g})} \rightarrow \text{I}^-_{(\text{aq})}$	$\Delta H_4 = -293$
$\text{Ag}^+_{(\text{g})} + \text{I}^-_{(\text{g})} \rightarrow \text{AgI}_{(\text{s})}$	$\Delta H_1$

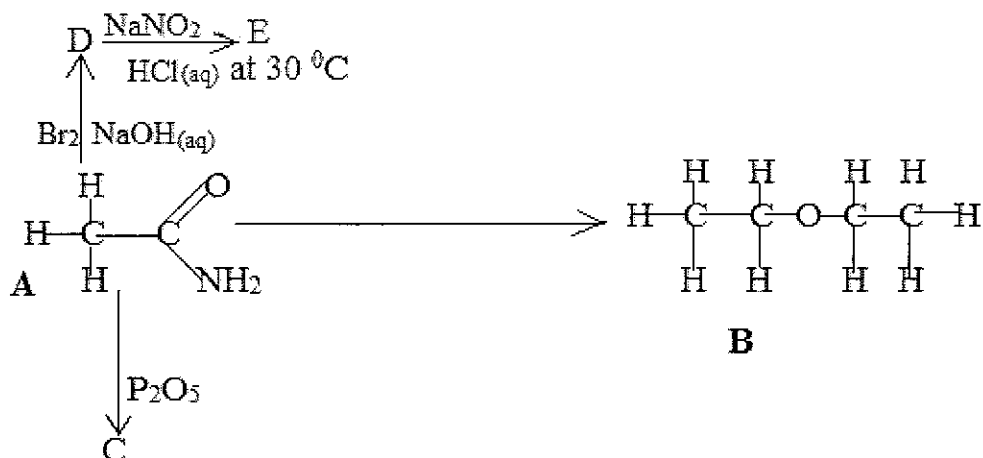
- a) Define the term “ **enthalpy of lattice formation** ” (2 marks)
- b) Write the chemical symbol or formula of a reagent that can be used to test for the presence of iodide ions in aqueous solution and describe the observable change. (2 marks)
- c) Calculate the enthalpy of lattice formation of  $\text{AgI}$ ,  $\Delta H_1$ . (4 marks)
- d) Explain why the use of butane alkane is preferred for use in combustion gas cylinders rather than ethane alkane. (2 marks)
- 19) a) Two different organic molecules react to form an amide bond in the resultant molecule.
- (i) Write the structural formula of the resultant molecule showing the location of the amide bond. (1 mark)
- (ii) Explain the reason why amide bonds are strong. (2 marks)

b) Study the diagrams given below and answer the questions that follow:



Explain why chloroethanoic acid is a stronger acid than ethanoic acid. (2 marks)

c) Study the diagram given below and answer the questions that follow:



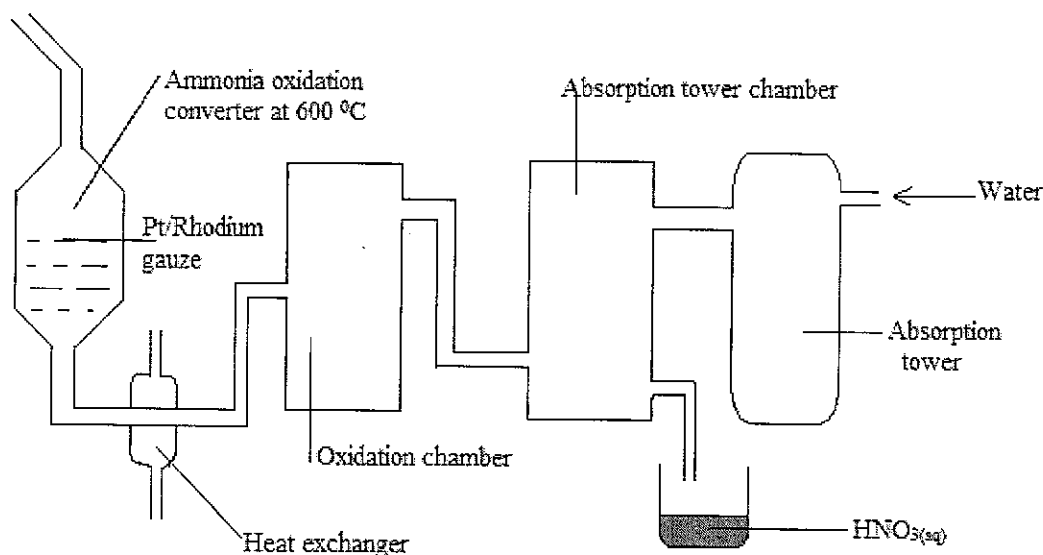
(i) Write the semi-developed molecular formula of organic substance: C, D and E

**(2 marks)**

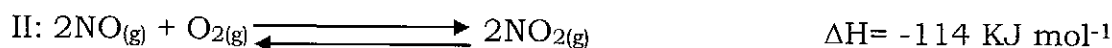
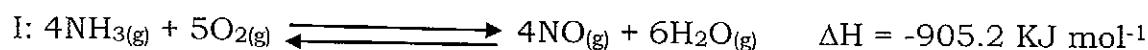
(ii) Write different chemical equations of reactions (not more than 5 equations) that can be used to illustrate the conversion of 2 moles of organic substance A into 1 mole of substance B. Include reagents and conditions.

**(3 marks)**

20) Study the diagram given below for the production of nitric acid and answer the questions that follow:



Equations:



- a) Explain the effect of increasing the temperature (in the oxidation converter) on the position of equilibrium when NO is produced from NH<sub>3</sub> in equation I. **(2 marks)**
- b) Explain the importance of reduction of temperature of the reacting mixture by the heat exchanger. **(1.5 marks)**
- c) State the name of a substance (reagent) that can be used to test for the presence of concentrated nitric acid, HNO<sub>3</sub> and give the observable change. **(2 marks)**
- d) Explain the importance of platinum/Rhodium catalyst to the reacting mixture in the oxidation converter. **(1.5 marks)**
- e) State 1 physical properties of concentrated nitric acid, HNO<sub>3</sub> acid. **(1 mark)**
- f) Evaluate the importance of the manufacturing of nitric acid, HNO<sub>3</sub> to agricultural farmers in our society. **(2 marks)**