Catholic University Institute of Buea (CUIB)

2018/2019 ACADEMIC YEAR

Semester Examinations – February 2019

School	ENGINEERING		Department	Chemical	
Course Code	CME 211	Course Title	Process Analysis		
Status	C	Credit Value	4		
Date	28/02/2019	Venue	LH 2 LH 8	Time	8:00 - 11:00
Course Master(s)	Mr Nkongho Epey Lewis				

Level: Sophomore **Duration:** 3 hours

Instructions: Answer **ALL** Questions; Calculators are allowed

Take RMM Na=23; Cl=35.5 O=16; H=1; C=12

Question 1 DIMENSIONAL ANALYSIS (10 MARKS)

It was found in an experiment that the pressure difference (ΔP) between two ends of a pipe in which a fluid is flowing is a function of the pipe diameter (d), the pipe length (l), the fluid velocity (u), the fluid density (ρ), and the fluid viscosity (μ). From your knowledge on dimensional analysis determine the equation that relates the above variables to obtain an equation containing only dimensionless groups of constants.

Question 2: STOICHIOMETRIC ANALYSIS (15 MARKS)

A common method used in manufacturing sodium hypochlorite (NaOCl) bleach is by the reaction:

$$Cl_2 + 2NaOH \rightarrow NaCl + NaOCl + H_2O$$

Chlorine gas is bubbled through an aqueous solution of sodium hydroxide (NaOH), after which the desired product is separated from sodium chloride (NaCl - a by-product of the reaction). An aqueous solution of NaOH that contains 1150g of pure NaOH is reacted with 850g of chlorine gas. The NaOCl formed weighs 600g.

a) What is the limiting reactant (proof)? **(5 Marks)**
b) What is the percentage excess of the excess reactant used? **(3 Marks)**
c) What is the degree of completion of the reaction, expressed as moles of NaOCl formed to the moles of NaOCl that would have been formed if the reaction had gone to completion? **(3 Marks)**
d) What is the yield of NaOCl per amount of chlorine gas used (on a weight basis)? **(4 Marks)**

Question 3 STOICHIOMETRIC ANALYSIS (10 MARKS)

In an industrial preparation of ammonia, $2m^3$ hydrogen gas and, $1m^3$ of nitrogen gas were introduced into a reactor at a temperature of 727°C and a pressure of 1 atm.

Take R= 0.082 $LatmK^{-1}mol^{-1}$

a) Calculate the limiting reagent in the reactor. (4 marks)

b) If after a certain time t, during the course of the reaction, 5 moles of nitrogen gas was found present in the reactor, calculate the number of moles of hydrogen and the percentage conversion. (6 marks)

Question 4 THERMODYNAMICS (5 MARKS)

Determine whether or not the decomposition of calcium carbonate at 298K in a blast furnace is possible. If not feasible, then determine the approximate value of the decomposition temperature of the carbonate. The following data is given at 298 K;

- Standard enthalpy change of formation of calcium oxide = -635kJ/mol
- Standard enthalpy change of formation of carbon dioxide = -394kJ/mol
- Standard enthalpy change of formation of calcium carbonate = -1208kJ/mol
- Standard entropy change of calcium oxide = 38J/K/mol
- Standard entropy change of carbon dioxide = 214J/K/mol
- Standard entropy change of calcium carbonate = 92J/K/mol (5marks)

Question 5 CHEMICAL EQUILIBRIA (10 MARKS)

$CO_{(g)} + H_2O_{(g)} \rightleftharpoons CO_{2(g)} + H_{2(g)}$

If the water-gas shift reaction (above) proceeds to equilibrium at a temperature T(K).

a) Use the mole fractions to derive the equilibrium constant expression (Ky) beginning with one mole of reactants. (4 Marks)

b) At T = 1105 K, Ky= 1.0, and suppose the feed to the reactor contains 1.00 mol of CO, 2.00 mol of $H_2O$and the reaction mixture comes to equilibrium at 1105 K, calculate the equilibrium composition and the conversion of the limiting reactant. (6 Marks)