



**THE MOMBASA POLYTECHNIC UNIVERSITY COLLEGE**

***Faculty of Engineering & Technology***

**DEPARTMENT OF MECHANICAL AND AUTOMOTIVE ENGINEERING**

**DIPLOMA IN CHEMICAL ENGINEERING**

**STAGE III SEMESTER II EXAMINATIONS**

**APRIL/MAY 2010 SERIES**

**REACTOR & CONTROL**

**TIME: 2 HOURS**

**Instructions to Candidates**

You should have the following for this examination:

- Two Answer Booklets.
- Scientific Calculator/SMP Tables.
- Drawing Instruments.

This paper consists of **FIVE** Questions in **THREE** Sections **A**, **B** and **C**.  
Question **ONE** is **COMPULSORY**.

Answer **TWO** other Questions in **THREE** Sections **B** and **C**.

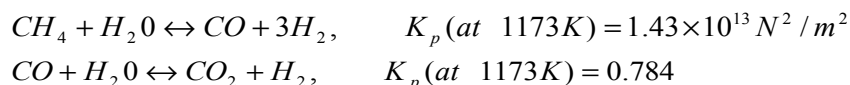
Maximum marks for each part of a question are indicated.

### **Question ONE**

- (a). (i). State and explain **THREE** essential aspects of instrumentation systems. **(3 Marks)**
- (ii). Differentiate between Accuracy and Decision. **(2 Marks)**
- (b). Give **THREE** advantages of rising bode analysis. **(3 Marks)**
- (c). Explain the following:
- (i). Phase cross over frequency
- (ii). Gain cross over the frequency **(2 Marks)**
- (d). (i). Using the information from question **TWO**, what will be the effect on the composition of the exits gas by increasing the total pressure in the reformer? Why for ammonia manufacture, pressure? The reforming step is follow by shift conversion:
- $$CO + H_2O \leftrightarrow CO_2 + H_2$$
- Absorption of  $CO_2$ , and ammonia synthesis according to the reaction:
- $$N_2 + 3H_2 \leftrightarrow 2NH_3$$
- (5 Marks)**
- (ii). Define the following terms:
- (i). Homogeneous catalysis and give at list one example of such use. **(1½ Marks)**
- (ii). Heterogeneous catalysis and give at list one example of such use. **(1½ Marks)**
- (iii). What is a catalyst promoter, a catalyst inhibitor and catalyst poison? **(2 Marks)**

### **Question TWO**

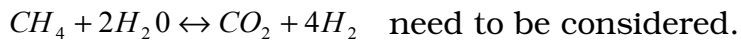
In process for the production of hydrogen for the manufacture of ammonia, natural gas is to be reformed with the steam according to the reaction with steam according to the following reactions:



The natural gas is mixed with steam in the mole ratio  $1CH_4 : 5H_2O$  and passed into a catalytic reactor which operates at a pressure of  $3MN/m^2$  (30 bar). The gases leave the reactor virtually at equilibrium at 1173K.

- (a). Show that for every 1 mole of  $CH_4$  entering the reactor, 0.950 mole reacts, and 0.44 moles of  $CO_2$  is formed. **(13 Marks)**

- (b). Explain why other reactions such as:

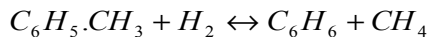


- (c). By considering the reaction:

$CO \leftrightarrow CO_2 + C$  for which  $K_p = P^2Co_2 / P^2Co = 2.76 \times 10^{-7} N^2 / m^2$  at 1173K, show that carbon deposition on the catalyst is unlikely to occur under the operating conditions. **(4 Marks)**

### **Question THREE**

A preliminary assessment of process for the hydrodealkylation of toluene to be made. The reaction involve is:



The feed to the reactor will consist of hydrogen and toluene in the ratio  $2H_2 : 1C_6H_5CH_3$ :

- (a). Show that with this feed and an outlet temperature of 900K, the maximum conversion attainable, that is equilibrium conversion, is 0.996 based on the toluene. The equilibrium constant of the reaction at 900 K is  $K_p = 227$ .

**(13 Marks)**

- (b). Calculate the temperature rise which would occur with the feed if the reactor was operated adiabatically and the products were withdrawn at equilibrium. For the reaction at 900K,  $-\Delta H = 50,000 kJ / kmol$ .

**(4 Marks)**

Special heat capacities at 900K ( $kJ / kmol K$ ):  $C_6H_6 = 198$ ,  $C_6H_5.CH_3 = 240$ ,  $CH_4 = 67$ ,  $H_2 = 30$ .

**SECTION C**

**Question FOUR**

- (a). Draw a bode diagram of this process.
- (b). (i). State if the system is stable or unstable.
- (ii). Find the phase margin and gain margin.

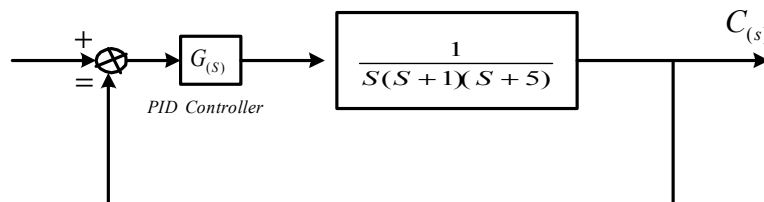
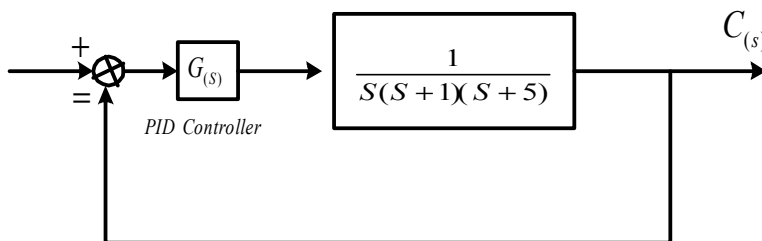
Frequency Cycles/Min	Gain	Phase Angle Degree
0.06	1.6	-68
0.08	1.4	-88
0.1	1.2	-105
0.15	0.84	-145
0.2	0.61	-177
0.3	0.35	-235

**(20 Marks)**

**Question FIVE**

- (a). PID Controller was used to control the system below. The PID controller has the transfer function.

$$G(s) = K_p \left[ 1 + \frac{1}{Ti} + Tds \right]$$



Determine

**(7 Marks)**

(b). Serious accidents occur at random in a particular manufacturing industry at a rate of 1.5 per week. Assuming Poisson distribution, determine the probability of less than two accidents occurring during:

- (i). a given week
- (ii). a four week period

**(6 Marks)**

(c).(i). Determine the probability that a random variable of  $Z$  :

- (I). Lies between  $Z = -1.4$  to  $Z = 0.7$ .
- (II). Is greater than 2.5.

(ii). The mean diameter of a sample of 400 roller is 22.50mm and The Standard Deviation is 0.50mm. Rollers are acceptable with diameters  $22.36 \pm 0.53mm$ . Determine the probability of a roller being within the acceptable limits.

**(7 Marks)**