UNIVERSITY OF GHANA
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UNIVERSITY OF GHANA
FACULTY OF ENGINEERING SCIENCES

SECOND SEMESTER EXAMINATIONS, 2012/2013

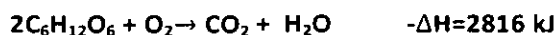LEVEL 300: BACHELOR OF SCIENCE IN ENGINEERING

FPEN 306: Chemical Reaction Engineering

TIME ALLOWED: TWO (2) HOURS

Instructions:

1. Answer All questions.
2. Calculators allowed
3. Graph paper provided.

1. A human being (80kg) consumes about 6400kJ of food per day. Assume that the food is all glucose and that the overall reaction is

   $2C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$ -ΔH=2816 kJ

   i. Balance the equation
   ii. Find man's metabolism (rate of living, loving, and laughing) in terms of moles of oxygen per m^3 of person per second. (estimate the density of man to be $\rho = 1000\frac{kg}{m^3}$)

2. Consider a municipal water treatment plant for a small community. Waste water, 32 000m3/day, flows through the treatment plant with a mean residence time of 8hr, air is bubbled through the tanks, and microbes in the tank attack and break down the organic material

   $$(\text{Organic waste}) + O_2 \xrightarrow{\text{microbes}} CO_2 + H_2O$$
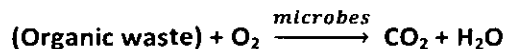
   A typical entering feed has a BOD (biological oxygen demand) of 200 mgO$_2$/liter, while the effluent has a negligible BOD.

   i.   Draw a diagram to represent the process
   ii.   Find the rate of reaction, or decrease in BOD in the treatment tanks.
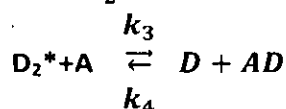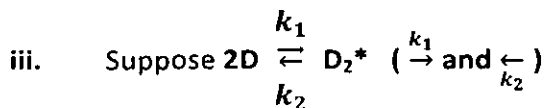
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3. The irreversible reaction

$$A + D = AD$$
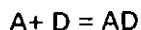
Has been studied kinetically, and the rate of formation of product has been found to be well correlated by the following rate equation:

$$r_{AD} = kC_D^2 \dots \text{ independent of } C_A.$$

What will be the rate expression

    i.   If the reaction was elementary

    ii.   Compare the expression of the elementary rate with the rate given above

    iii.   Suppose $2D \underset{k_2}{\overset{k_1}{\rightleftarrows}} D_2^*$ $\left(\overset{k_1}{\rightarrow} \text{ and } \underset{k_2}{\leftarrow} \right)$

$$D_2^* + A \underset{k_4}{\overset{k_3}{\rightleftarrows}} D + AD$$

        1. How many elementary reactions are involved in iii?

        2. The chemistry of the reaction suggests that the intermediate consists of an associate ion of reactant molecules and that a chain reaction does not occur find r_{AD}?

            a. If $r_{D2^*} = 0$

            b. If $k_2 \ll 1$

            c. If $k_4 \ll 1$

4. A reaction in which one of the products of reaction acts as a catalyst is called an autocatalytic reaction. The simplest such reaction is

$$A + R \rightarrow R + R$$
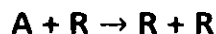
    i.   Write the rate equation $-r_A$.

    ii.   Since $C_0 = C_A + C_R =$ constant write the rate of change as a function of C_A.

    iii.   Find C_A as a function of time t by integration.