RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree
Third Year- Semester 1I Examination-September/October 2014

CHE 3306- THEORETICAL FUNDAMENTALS OF CHEMICAL INDUSTRY

Answer **All** questions Time allowed: **3** hours

Equals marks for each question

The standard symbols can be used without a definition. All symbols used in questions denote standard meaning. R = 8.314 J mol^{-1} K^{-1}

1.

(a) State five global chemical industries highlighting their major product lines.

(b) A single reaction in an ideal reactor is hardly encountered in the industrial scale. Briefly discuss this statement considering steam cracking of ethane as an example.

(c) What is meant by "a runaway reaction" in an industrial process?

(d) Briefly discuss the importance of mass transport and chemical kinetics in reactor designing at industrial scale.

2.

(a) State the twelve principles of green chemical industry.

(b) Discuss green chemical synthesis process of adipic acid using glucose and E. coli. State two uses of adipic acid.

(c) Briefly explain the operational principle of catalyticconverter used in automobiles for the mitigation of noxious gases.

(d) What is bio-fuel? What are its advantages over fossil fuel? Is bio-fuel a green industry? discuss

3.

(a) Define following terms:

i. Extent of a reaction ii. Selectivity iii. Conversion

(b) A generic chemical reaction is shown as below:

$$a_1A + a_2B = a_3C + a_4D$$

State it in standard notation.

(c) Write mathematical expressions to calculate extent of the reaction, and conversion.

(d) Ammonia synthesis reaction is shown below. $N_2 + 3H_2 = 2NH_3$. Initially 2 and 3 moles of N_2 and H_2 respectively are present in the system. What is the limiting species? Deduce a stoichiometric matrix for the reaction using a standard notation.

4.

(a) Prove that the general mass balance equation for a given reactor is

$$F_{jo} - F_j + \int r_j dV = \frac{dN_j}{dt}$$

(b) Briefly explain the principle of following ideal reactors.

(i) Batch reactor
(ii) Continuous stirred tank reactor
(iii) Plug flow reactor

State the mass balance equation of the batch reactor. Hint: use the answer shown in Section a.

(c) Prove that the unsteady state mass balance equation of the plug flow reactor with a constant cross section is

$$\frac{\partial C_j}{\partial t} = -\frac{\partial F_j}{\partial V} + r_j$$

(d) If and only if the volumetric flow rate and the radial diameter of a plug flow reactor are constant, deduce an equation for the steady state mass balance of the plug flow reactor.

5.

(a) Define following terms;

(i) Self diffusion (ii) Heat flux (iii) Mass flux

(b) State the Fick's first law of diffusion. Relate heat and charge transfer fluxes in analogous manner to Fick's first law.

(c) Aluminum is to be diffused into silicon single crystal. At what temperature will the diffusion constant be 5×10^{-11} cm^2/s (Given $E_A = 315$ kJ/mole; $D_0 = 170$ cm^2/s.

(d) Explain the chemical principle based on diffusion in the production of steel. Discuss the major advantage of the process.

6.

(a) State the difference between steady state and none-steady diffusion of materials.

(b) State the Fick's 2nd law of diffusion. Fick's 2nd law has a solution of the form

$$\frac{C_2 - C}{C_2 - C_0} = erf\left(\frac{x}{2\sqrt{Dt}}\right)$$

Identify all terms therein. State the relevant initial and boundary conditions.

(c) To increase its corrosion resistance, chromium (Cr) is diffused into steel at 980°C. If during diffusion the surface concentration of chromium remains constant at 100%, how long will it take (in days) to achieve a Cr concentration of 1.8% at a depth of 0.002 cm below the steel surface? (D_o = 0.54 cm2/s; E_A = 286 kJ/mol) Note erf (1.67) = 0.982.