



**RAJARATA UNIVERSITY OF SRI LANKA  
FACULTY OF APPLIED SCIENCES**

**B.Sc. (General) Degree  
Third Year- Semester II 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.  $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$

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.

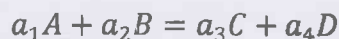
- (a) State the twelve principles of green chemical industry.
- (b) Discuss green chemical synthesis process of adipic acid using glucose and *E. coli*. State two uses of adipic acid.
- (c) Briefly explain the operational principle of catalytic converter used in automobiles for the mitigation of noxious 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:



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  $5 \times 10^{-11} \text{ cm}^2/\text{s}$  (Given  $E_A = 315 \text{ kJ/mole}$ ;  $D_0 = 170 \text{ cm}^2/\text{s}$ ).

- (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 2<sup>nd</sup> law of diffusion. Fick's 2<sup>nd</sup> law has a solution of the form

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

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? ( $D_0 = 0.54 \text{ cm}^2/\text{s}$ ;  $E_A = 286 \text{ kJ/mol}$ ) Note  $\operatorname{erf}(1.67) = 0.982$ .