RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
Third Year - Semester I Examination – September / October 2019

CHE 3206 – CHEMICAL AND PROCESS TECHNOLOGY

Time: Two (02) hours

Answer only four (04) questions.
Use of a non-programmable calculator is permitted.

1. a) State principles of green chemical industry.
   b) What is meant by sustainable development? How it relates to green technology. Critically discuss.
   c) State conventional and green chemical production of adipic acid. Discuss the advantages of green chemical method of adipic acid production.
   d) Define the terms yield and atom economy. Why atom economy is sustainable in modern chemical industry.

(100 marks)

2. a) Discuss the evolution of modern chemical industry.
   b) Discuss the contact process of sulfuric acid production highlighting possible environmental hazards.
   c) State essential steps in Solvay process.
   d) Discuss industrial uses of sulfuric acid and sodium carbonate.

(100 marks)

3. a) Derive the general mass balance equation. All symbols carry standard meaning.

$$F_{A0} - F_A + \int r_A dV = \frac{dN_A}{dt}$$

   b) State the mass balance equations of standard chemical reactors used in industry. Answer should carry at least three ideal reactions. State all assumptions made clearly.
   c) Identifying the reactor type, discuss the Haber process of ammonia production.
   d) Human digestive system can be equated to several types of ideal reactors. Identify them all and rationalize the answer.

(100 marks)

4. a) Define following terms:

(i) Vacancy diffusion (ii) Self diffusion (iii) Steady and non-steady state diffusion

b) State Fick's first law of diffusion identifying all terms. What are the conditions require or validity of Fick's first law?

c) Write down analogous equations to illustrate current and heat transfer processes.

d) There is a differential nitrogen pressure across a furnace wall made of steel measuring 2.22 mm in thickness. The concentration of nitrogen at the inner surface of the wall is held constant at 9.99 kg m^{-3}, while the concentration at the outer surface of the wall is held constant at 1.11 kg m^{-3}. The area of the wall is 3.33 m^2, and the diffusivity of nitrogen in steel at the furnace operating temperature is $D_N = 3.091 \times 10^{-10}$ m^2 s^{-1}.

What is the total rate loss of nitrogen from the furnace at steady state? Express your answer in units of kg s^{-1}. (100 marks)

5. Answer part I **OR** part II

Part I

a) A particular solution for Fick's second law is given below. Identify all terms shown in the solution. State all boundary and initial conditions used for this solution. State Fick's second law of diffusion.

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

b) 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? ($D_o = 0.54$ cm^2 s^{-1}; $E_A = 286$ kJ mol^{-1}).

i. Calculate diffusion coefficient at 980 ^{0}C.
ii. 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?

Note: erf (1.62) = 0.982 (100 marks)

Part II

a) State the meaning of permeate, concentrate and feed flow as used in membrane treatment industry.

b) Suggest an improvement plan to sustain the reverse osmosis treatment plants installed at the Faculty of Applied Science Rajarata University.

(100 marks)

— END —