B.E. CHEMICAL ENGINEERING FOURTH YEAR SECOND SEMESTER – 2022

SUBJECT: HIGH POLYMER TECHNOLOGY

FM-70 Time-4 hrs

Q1 and Q2 must be answered. Attempt any two from the rest.

1. (a) United Nigeria Textile Ltd is making nylon 6,6 from hexamethylenediamine and adipic acid. One batch is made on every 8-h shift. In each batch equimolar reactants are used and conversion is usually 98.0%. At the end of the run the bulk product is extruded and chopped into pellets. **(10)**

i. Calculate the number-average molecular weight.

ii. The afternoon shift operator dumped in too much adipic acid. From his records you calculate that the mole ratio was 2% excess adipic acid. If the batch went to the usual conversion, what was its number-average molecular weight?

iii. The night shift operator weighed things correctly but fell asleep and let the reaction run too long —99% conversion. What will be the M_n of this batch?

(b) The data for the bulk polymerization of styrene at 60°C with benzoyl peroxide as initiator are $[M] = 8.35 \times 10^3$ mol/m^3 $[I] = 4.0$ mol/m^3 $K_p^2/k_d = 1.2 \times 10^{-6}$ m^3/mol-s

If the initial rate of polymerization of styrene is 0.026 mol/m^3-s and the spontaneous decomposition of benzoyl peroxide in styrene is 2.8×10^{-6} s^{-1}, what is the efficiency of the initiator? **(6)**

(c) The energies of activation for the polymerization of styrene with di-tertiary-butyl peroxide as initiator are: $E_d = 33.5$ kcal/mol; $E_p = 7.0$ kcal/mol; $E_t = 3.0$ kcal/mol

Calculate the relative (i) rates of propagation and (ii) degree of polymerization (X_n) if the polymerization temperature is changed from 50°C to 60°C. **(6)**

where $E = E_p - \frac{E_t}{2} + \frac{E_d}{2}$.

(d) Consider a polyesterification reaction.

i. Suppose 1.0 mol each of dicarboxylic acid and glycol is used. What is the degree of polymerization when the extent of reaction is 0.5, 0.99, and 1.0?

ii. Suppose 101 mol glycol is reached with 100 mol of the dicarboxylic acid. What is the maximum degree of polymerization?

iii. Suppose the dicarboxylic acid contains 2 mol% monoacid impurity. What is the maximum degree of polymerization? **(8)**

[Turn over

2. Write short notes on (any Four): Emulsion polymerization; Blow Molding; Viscoelastic model; Chain Transfer Reaction, Metathesis Polymerization **(20)**

3. (a) Show the formation of possible branch points/3D network structure via considering the reaction between ethylene diamine and 1,2 epoxy propane.
(b) Explain all the stages of glass-rubber transition behaviour. **(5+5)**

4. Write all the steps of injection molding operation of plastic fabrication (with schematics) **Or** Discuss the working principle of Gel permeation Chromatography (with schematics). **(10)**

5. Explain the observations: **(2×5 =10)**
i. Atactic polystyrene can be oriented but does not crystallize; rubber on the other hand, bothcrystallizes and becomes oriented when it is stretched.

ii. Poly(vinyl alcohol) is made by the hydrolysis of poly(vinyl acetate). At room temperature, pure poly(vinyl) acetate), i.e., at 0% hydrolysis, is insoluble in water. However, as the extent of hydrolysis is increased, the polymers become more water soluble up to 87% hydrolysis, after which further hydrolysis decreases water solubility.

iii. Toluene and xylene have approximately the same cohesive energy density (CED), but xylene is a more convenient solvent for polyethylene.

iv. α-Methylstyrene polymerizes much less readily than styrene.

v. Glass transition temperature is 2^{nd} order.