Maximum Marks: 60  
Credits: 04  
Duration: Three Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No.  

1(a) What is the highest value of $K$ for which the open loop pulse transfer function is stable? 
\[ \frac{Kz}{(z-0.25) (z-0.5)} \]
Draw the root locus diagram and apply modified Routh's test and check the $K_{\text{max}}$ value.  

OR

1'(a) A first order element having $K=1$ and time constant of unity and an integrating element ($K=1$) are connected together. The output from the first order element is sampled and then fed to the integrating element. Obtain the impulse modulated time output for this system when subjected to a unit impulse input. Assume sampling time to be unity.

1(b) Obtain the transfer function of the feed forward controller, $G_f$ for the system shown in Figure 1.

[Diagram of a control system with transfer function $G(s) = \frac{1}{s+1}$ and $G_f = \frac{1}{6(s+1)}$]

What are the advantages and disadvantages of Feed Forward controller?

2(a) Tyreus and Luyben controller settings are claimed to be more suitable for process control applications. Give the recommendations for PI and PID controllers. Tune a PI controller for the following OLTF using Tyreus-Luyben recommendations.
\[ G(s) = \frac{1}{(s+1) (0.8s+1) (0.2s+1)} \]

OR

Contd.....
2(a) Discuss the effect of transportation lag on stability of the control system with the help of an example.

An experimentally determined asymptotic AR curve for the control of a tubular reactor temperature to the cooling water flow rate is shown in Figure 2. Determine the transfer function.

![Figure 2](image)

2(b). Write short notes on the following:

- Cascade control of bottom temperature of distillation column
- Ratio control system for control of alkali feed rate based on the acid flow rate in the neutralization tank used in an effluent treatment unit.

3(a). Differentiate between lumped parameter systems and distributed parameter systems with example.

3(b). If \( C_r = \text{Rs } 60 \text{ kg mol} \), \( C_v = \text{Rs } 1/(\text{hr})(\text{m}^3) \), \( k = 120 \text{ m}^3/(\text{kg mol})(\text{hr}) \), and \( A_f = 1.0 \text{ kg mol/m}^3 \), determine the optimum design of isothermal CSTR for producing \( G = 100 \text{ kg moles per hour} \) of a product \( B \) by reaction

\[ A \rightarrow B \]

where reaction rate is given by

\[ \frac{d[A]}{dt} = kA^2 \]

Derive the equations used.
4. Develop a linearized model of a non-isothermal CSTR. State Assumptions clearly.

Show that the linearized CSTR model developd above can be written in the state-space form
\[ \frac{d\mathbf{x}}{d\tau} = \mathbf{Ax} + \mathbf{By} + \mathbf{Cv} \]
\[ Z = \mathbf{Ex} \]
\( \mathbf{A} = N \times N \) matrix
\( \mathbf{B} = N \times 2 \) matrix
\( \mathbf{C} = N \times N \) matrix
\( \mathbf{C} = N \times N \) matrix

Derive state-space models when
(a) Both \( C_A \) & \( T \) are measured, where \( C_A \) is concentration of \( A \) in reactor and \( T \) is reactor temperature.
(b) only \( T \) is measured

OR

4' It is desired to separate a binary feed in a distillation column. Develop a process and model along with material and energy balance equations for

(i) Binary Batch Distillation
(ii) Binary Continuous Distillation

State clearly the assumptions made.
Q.No. 1(a) Derive the equation of a first order reaction using the segregation model when the RTD is equivalent to an ideal PFR and an ideal CSTR. Compare these conversions with those obtained from the design equation. Draw the RTD curve for a CSTR and PFR in series along with its E(t) expression.

OR

1(a) The following data were obtained from a step trace input to the reactor:

<table>
<thead>
<tr>
<th>t(min)</th>
<th>0</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
</tr>
</thead>
<tbody>
<tr>
<td>C (mg/dm³)</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>7</td>
<td>8</td>
<td>8.5</td>
<td>8.9</td>
<td>9.2</td>
<td>9.5</td>
<td>10</td>
</tr>
<tr>
<td>t(min)</td>
<td>20</td>
<td>21</td>
<td>22</td>
<td>23</td>
<td>24</td>
<td>25</td>
<td>26</td>
<td>27</td>
<td>28</td>
<td>29</td>
<td>30</td>
</tr>
<tr>
<td>C (mg/dm³)</td>
<td>11</td>
<td>15</td>
<td>20</td>
<td>22</td>
<td>23</td>
<td>23.5</td>
<td>24</td>
<td>24.3</td>
<td>24.5</td>
<td>24.5</td>
<td>24.5</td>
</tr>
</tbody>
</table>

i. Develop a model that is consistent with the experimental data.

ii. Evaluate all the model parameters.

1(b) Describe briefly the procedure for the estimation of model parameters when the reactor is modelled as two CSTRs with interchange.
2(a). A mass transfer–limited reaction is being carried out in two reactors of equal volume and packing, connected in series. Currently 86.5% conversion is being achieved with this arrangement. It is suggested that the reactors be separated and the flow rate be divided equally among each of the two reactors as shown below (Figure 1) in order to decrease the pressure drop and hence the pumping requirements. In terms of achieving a higher conversion, was this a good idea? [07]

![Diagram of two reactors connected in series](image)

2(b) Develop the design equation and give the mass transfer correlation for the monolith reactor. Explain when the reaction rate is limiting, the mass transfer effects are not important. [08]

OR

2'(b) Derive the expression for the internal effectiveness factor for a first–order reaction in a spherical catalyst pellet. How can the rate of reaction be increased? Explain the Weisz-Prater criterion for internal diffusion. [08]

3. A first order, heterogeneous, irreversible reaction is taking place within a catalyst pore which is plated with platinum entirely along the length of the pore as shown in Figure 2. The reactant concentration at the plane of symmetry (i.e., equal distance from the pore mouths) of the pore is equal to one-tenth the concentration of the pore mouth. The concentration at the pore mouth is 0.001 g mol/dm³, pore length is 0.0002 cm, and the diffusion coefficient is 0.1 cm²/s.

i. Derive an equation for the effectiveness factor. [7+4+4]
ii. What is the concentration of reactant at L/2?

iii. To what length should the pore length be reduced if the effectiveness factor is to be 0.8?

4(a). Explain that the Van Heerden criterion of slope is a necessary but not a sufficient condition for the stable operation of an exothermic irreversible reaction in a CSTR.

OR

4(a)' What are the remedies commonly used to avoid the development of hot spots in a tubular reactor? If the slope of heat generation curve is increased, the problem of hysteresis will be removed. Explain.

4(b). Discuss the effect of variation of UA on the operation of the CSTR, where a reversible first order reaction is to be carried out in the reactor having volume of 5m³. Reactor temperature range is 300 to 450 K. Feed concentration is 1 kmole /m³ and feed temperature, T₀ is 300 K. Volumetric heat capacity of reaction mixture (pCp) = 800 kcal/m³, ΔT_ad = 100K.

k = 4x10⁸ exp (-7900/T), s⁻¹ and k' = 1x10¹⁰ exp (-9900/T), s⁻¹

Make the plot of conversion versus temperature with increasing values of UA.
2012-2013
M.TECH. (WINTER SEMESTER) EXAMINATION
PETROLEUM PROCESSING AND PETROCHEMICAL ENGINEERING
PETROCHEMICAL PROCESSES
PK-606

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all the questions.

Q.No.  Question  M.M.
1(a)  Explain the following with reference to petrochemical industries:  [3]
(i) Petrochemicals
(ii) Dry and Wet Natural Gas and which is valuable and why?

1(b)  Describe in brief the systematic development of petrochemical industrial in India with reference to name of the industries only?  [3]

1(c)  List the sources of petrochemical feedstocks with the help of schematic diagram?  [5]

1(d)  List one value added petrochemical derived from Methane and Acetylene OR from Ethylene and Propylene with chemical reactions?  [4]

2(a)  Explain the high value addition across various sectors (the structure of petrochemical industry) with the help of schematic diagram?  [6]

2(b)  Describe the steam cracking process with the help of process flow sheet and reactions for the production of olefins if the feedstock is a mixture of Ethane and Propane OR Naptha with reference to the effect of different process variables on yield and the role of steam.  [9]

Contd…….2
3(a) Define the Hydroformylation process with the help of chemical reactions and discuss in brief the merits and demerits of the catalyst employed in this process and the effect of operating parameters on the yield of the product.

3(b) Define the F.T process with the help of chemical reactions, catalyst and reactors.

**OR**

3′(a) Define the Carbonylation process with the help of reactions. List the merits of immobilized catalyst system over the conventional liquid rhodium catalyst for Carbonylation of methanol to acetic acid?

3′(b) During conversion of methanol to olefin, SAPO-34 and ZSM-5 are used as catalyst. SAPO-34 and ZSM-5 are selective towards which olefin?

3′(c) Though on paper oxidation reactions are very simple but are most difficult to carry out on commercial scale why? What is the role of diluents in the vapor phase oxidation process?

3′(d) Describe with the help of process flow sheet the oxidation and cleavage step for the manufacturing of Acetone and Phenol from Cumene using KBR process?

4(a) Define the disproportionation process with the help of reactions and explain why disproportionation is preferred over hydrodealkylation of alkyl aromatics?

4(b) Explain the isomerization process and its application in petrochemical industry?

4(c) Define esterification process. What are the major problems which affects the esterification reaction?

4(d) Define and classify hydrodealkylation processes used in industries?

4(e) Define catalytic alkylation process and also give the objectives of process?
2012-13
M.TECH. (WINTER SEMESTER) EXAMINATION
PETROLEUM PROCESSING & PETROCHEMICAL ENGINEERING
POLYMER AND COMPOSITES
PK-607

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No. Question M.M.
1(a) Differentiate between;
   (i). Cis and Trans polymers.
   (ii). Linear, branched and network polymer structures.
   (iii). Degradation and De-polymerization of polymers.
   (iv). Condensation and step polymerization. [7.5]

1(b) Differentiate between the step and addition polymerization mechanism. Also discuss [7.5]
the molecular weight growth as function of conversion in both the cases

OR

1' Consider a SMC designated as SMC – R65 containing E-glass fibers in a [15]
thermosetting matrix. The following data are known;

<table>
<thead>
<tr>
<th>E-glass Fiber</th>
<th>Polyester matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_f = 68.9$ GPa</td>
<td>$E_m = 3.45$ GPa</td>
</tr>
<tr>
<td>$\rho_f = 2540$ Kg/m3</td>
<td>$\rho_m = 1100$ Kg/m3</td>
</tr>
<tr>
<td>$l_f = 25.0$ mm</td>
<td></td>
</tr>
<tr>
<td>$d_f = 2.5$ mm</td>
<td></td>
</tr>
</tbody>
</table>

Calculate the tensile modulus, shear modulus and Possion’s ratio for the composite.

2(a) Differentiate the SSC for metals and polymers. Elaborate the various parameters [7.5]
affecting the nature of stress/strain curve for polymeric materials.
2(b) What do you mean by crystallinity of a polymer? How can we regulate the crystallinity during processing of polymer with its effect on the mechanical properties of polymer?

OR

2'(a) Write down the name of 4 polymers belonging to each of chain and step polymerization category. Differentiate between the step and chain polymerizations.

2'(b) Classify the non-Newtonian fluids with example. What is the difference between shear strain and shear strain rate? Give the shear rate range for various polymer processing methods.

3 A hybrid composite material is made up of 25% Carbon fiber by weight and 20% S-glass fiber by weight in an polyester matrix. If the densities of polyester, carbon fiber, S-glass fiber are 1100 kg/m3, 1750 kg/m3, and 2410 kg/m3 respectively. Calculate the density of composite.

OR

3' Explain the construction and working of Differential Scanning Calorimeter (DSC). Explain how you will relate the DSC curve with glass transition temperature, crystallization, melting and degradation of polymer.

4(a) Derive the expression for critical volume fraction of fiber in a composite. Explain the role of fiber below critical volume fraction in composite.

4(b) What do you mean by visco-elasticity? Why polymers are viscoelastic in nature? Differentiate between the creep and stress relaxation behaviour.
Q.No. | Question | M.M.
---|---|---
1(a) | What is the primary and secondary separation phenomenon in separator? Find out the terminal velocity of liquid droplets fall in the gas under gravitational force. | [5]

OR

1(a') | What are the important parameters for selecting multiple stages in “stage separation” operation? How numbers of stages are decided on the basis of these parameters? | 

1(b) | What are the important constituents of wellhead natural gas? Discuss briefly its impact in the natural gas. | [5]

1(c) | What type of separator(s) should be used for | [5]
1. Offshore production platform
2. High GOR well
3. Low to intermediate GOR well
4. Large liquid slugs and sand
5. Higher gas velocity

2(a) | Why mist extractor is used in the gas oil separator? Discuss the wire mesh mist extractor with its limitations. | [5]

OR

2 (a') | What is the function of inlet diverter? List the common type of diverters used. | 

Contd......2
2(b) What is the limit for water content in natural gas? Discuss briefly about the parameter that affects the water content in natural gas.

2(c) Explain the hydrate equilibrium with the help of neat diagram.

3(a) Discuss the types of natural gas hydrates with its cage description.

OR

3(a') Compare the chemical additives i.e. between glycol and methanol on the basis of injection technique for the prevention of gas hydrate.

3(b) How far can the pressure be lowered without expecting the hydrate formation for a 0.65 gravity gas if it is initially at 2000 psia and 100 °F?

3(c) Discuss the glycols dehydration process with the help of flow diagram.

OR

3(c') Discuss the relative cost of methanol, glycols & line heaters for preventing gas hydrates in the pipeline.

4(a) What do you understand by acid gases? What are the problems associated with it? What is the limit of acid gases in natural gas?

4(b) Discuss the different categories of acid gas removal processes.

4(c) Compare the different amine solvent used for acid gas removal.

OR

4(c') Describe the water wash process for acid gas removal with the help of flow sheet.

[Figure Enclosed]
Permissible Expansion of a 0.7-Gravity Natural Gas Without Hydrate Formation

See Caution on Figs. 20-19.

Fig. 2

Permissible Expansion of a 0.6-Gravity Natural Gas Without Hydrate Formation

See Caution on Figs. 20-19.

Fig. 1