2023-24

VII SEMESTER B.TECH. (ODD SEMESTER) EXAMINATION

PETROCHEMICAL ENGG.

COURSE TITLE: Process Dynamics and Control

COURSE CODE: PKC 4010

Maximum Marks: 60 **Credits: 04** **Duration: Two Hours**

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

Q.No.	Question	M.M.
1(a)	Comment on the differences between negative and positive feedback systems. Differentiate between lumped parameter and distributed parameter systems with the help of examples.	[3+4] (CO1)
1(b)	Develop the dynamic model for the thermal response of a stirred jacketed kettle with steam condensing in the jacket. Obtain the transfer functions relating kettle temperature with feed temperature and steam condensing temperature. Draw its block diagram. State all the assumptions made in the analysis.	[08] (CO1)
	OR	
1'(b)	A thermocouple Junction of Area A, Mass m, Heat capacity C, and emissivity is located in furnace that normally is at T_{is} °C. At these temperatures convective and conductive heat transfer to the junction are negligible compared with radiative heat transfer. Determine the linearized transfer function between the furnace temperature Ti and the junction temperature T_o. For the case m= 0.1 kg C = 0.12cal/(g)(°C) e= 0.7 A= 0.1 cm^2 T_{is}=1100 °C	[8] (CO1)

contd ....2.

Plot the response of the thermocouple to a 10 °C step change in furnace temperature.

2(a) Liquid is flowing through a cascade arrangement of two non-interacting tanks, each open at the top. Tank dimensions and operating conditions are: [10] (CO2)

Tank 1: Cross-sectional area- 2 m^2, Tank height- 4 m, Normal level –3m; Normal flow rate- 300l/min.

Tank 2: Cross-sectional area- 2 m^2 ; Tank height- 4 m, Normal level –3.7 m.

A workman carelessly dumps 1500 litres of liquid in to the top of the first tank, thinking that there is no chance of any liquid over flowing the walls of either tank.

(i). Obtain the variation of liquid levels in tank 1 and 2 as a function of time;

(ii). Check whether the tanks over flow. If yes, how much time after dumping of liquid and how long does it continue?

OR

2(a') A mercury- filled manometer is to be used to measure the pressure drop across an orifice meter. The meter will monitor the flow rate of air through a pipe. Specifications call for a decay ratio (not damping factor) of 0.3. The maximum pressure differential is such that a liquid column length of 75 cm. should suffice. Derive the equation used. [10] (CO2)

(i) Find the diameter of suitable glass tubing for the manometer. The specific gravity of mercury is 13.6 and the viscosity is 1.6 C.P.

(ii) Only tubing available has a diameter of 0.2 cm., what should be done to meet the specification.

2(b) A second order system when subjected to a unit step change gave a response with the following characteristics. Obtain the transfer function. [05] (CO2)

i. ratio of time first maximum/settling time (+2% band) = 0.4
ii. natural frequency = 1/3 rad/s
iii. ultimate response value = 2 units.

contd...3.

3(a) The set point in the feedback loop [Gc= 1.5, Gp = 4/ (s+1) (2s+1), Gm= 1] is given a step change of magnitude 5 units. Determine the maximum value of C, (Controlled output) and the time at which it occurs, the offset and the period of oscillation. [9] (CO3)

(b) What are the factors affecting the choice of a controller? Discuss the motivation for addition of integral and derivative control modes with the proportional control. [3+3] (CO3)

A unit step change is given to the input to a PID controller. If the controller gain is 10, the integral time is 1, and the derivative time is 0.5, obtain an expression for the response of the controller.

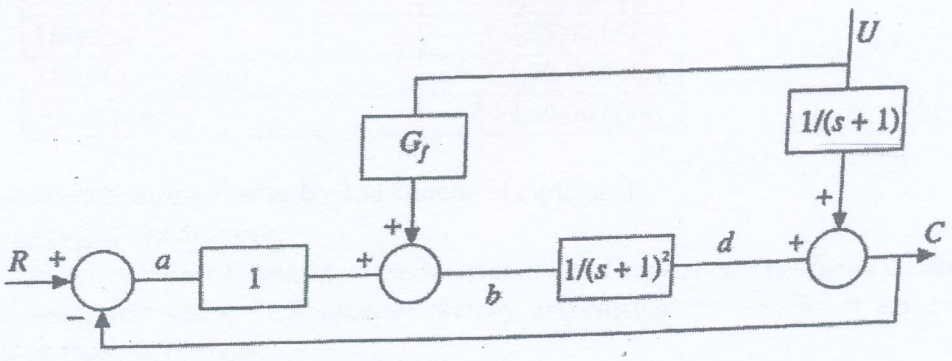
OR

3' (b) What is the major advantage of the Routh –Hurwitz criterion for examining the stability of the feedback control system? What conclusions can be drawn if one element in the first column of the Routh array is zero? [3+3] (CO3)

Determine the stability of the open loop transfer function, K/ s^2+s+20 K.

4(a) A catalytic reactor after deposition of carbon is regenerated by burning off the carbon deposits using air or oxygen. The combustion process produces high temperatures. To avoid excessive temperatures, what type of control action will be recommended. Draw the schematic diagram for the control system employed. [5] (CO4)

4(b) Obtain G_f (transfer function for feed forward control) for the system shown below: [5] (CO4)



contd.... 4.

4(c) Write short notes on any two of the following : [2.5+2.5] (CO4)

- Samplers and hold elements
- Ideal impulse sampler
- Discrete time model of a digital PI controller

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B.TECH. (ODD-SEMESTER) EXAMINATION
PETROCHEMICAL ENGINEERING
PLANT DESIGN AND ECONOMICS
PKC4030

Maximum Marks: 60 **Credits: 04** **Duration: 2 Hours**

Answer all the four questions.
Assume suitable data if missing.
Use of calculator is allowed.

Q.No.	Question	M.M. & CO
1	***Answer <u>any eight</u> of the following:***	[8]
	i. A problem has occurred in the measuring element of a level-indicating controller in a batch reactor. To what principal diagram should you refer to troubleshoot the problem?	CO1 & CO2
	ii. When would one purposely add an inert material to a feed stream?	
	iii. What is a flowshop plant?	
	iv. Mention the structure of solving a chemical product design problem.	
	v. Give any one reason why operation of a process at greater than 250°C is undesirable.	
	vi. Mention the differences and similarities between interest, inflation, and the time value of money.	
	vii. What is depreciation? How it affects the economic analysis of a new chemical process.	
	viii. What economic criterion would you use to choose the best piece of equipment among three alternatives, each with a different operating cost, capital cost, and equipment life?	
	ix. What are the advantages of probabilistic risk analysis?	
	(b) The following cost information was obtained from a design for a 1,00,000 tonne/y nitric acid plant:	[4] CO2

Fixed Capital Investment	₹ 90,00,00,000
Raw Materials Cost	₹ 65,00,00,000/y
Waste Treatment Cost	₹ 8,00,00,000/y
Utilities	₹ 2,95,00,000/y
Direct Labor Cost	₹ 1,90,00,000/y
Fixed Costs	₹ 12,50,00,000/y

Determine the manufacturing cost in ₹/y and ₹/tonne of nitric acid.

2	**(a)** ***Answer <u>any two</u> of the following:***	[3]
	i. The process by which an engineer uses information and creates new heuristics consists of three steps, also called PAR process, thereby maximizing the benefits of experience. Mention those three steps.	CO3
	ii. Recycles are also used for heat removal purposes. Explain how?	
	iii. How many simple distillation columns are required to purify a stream containing four components into four "pure" products?	

Contd....2.

(b) In general, when using cooling water (cw) as a utility, the outlet temperature of the water leaving any process exchanger and returning to the cooling tower is limited to about 40°C to avoid excessive fouling in the process exchangers. In a series of laboratory experiments on fouling, the inlet cw temperature was fixed at 30°C, and the dimensionless fouling ratio was recorded for exit cooling water temperatures in the range of 36°C to 46°C. [4] CO3

Cooling Water Exit Temperature, °C	Dimensionless Fouling Ratio
36	1.11
38	1.05
40	1.00
42	0.86
44	0.74
46	0.64

The fouling ratio is simply the ratio of the time between scheduled cleanings of the exchanger tubes compared to the time required at 40°C. For example, if an exchanger with a cw exit temperature of 40°C requires cleaning once a year (12 months), then an exchanger with a cw exit temperature of 46°C requires cleaning every (0.64)(12) = 7.68 months. The advantage of using higher cw exit temperatures is that less cooling water flow is required; hence, the pumping costs for cw are lower. For a typical heat exchanger in a process with an exit cw temperature of 40°C, the yearly pumping and cleaning costs are $400/y and $2400/y, respectively. Using these costs and the information in the table above, determine the optimal cw exit temperature.

Assume that the pumping costs are proportional to the flow of cooling water, that they include an amortized cost for the pump and the cost of electricity to run it, and that the cost of the heat exchanger is essentially unchanged for small differences in the cw exit temperature.

(c) Write the general sequence of events that a user should follow in order to set up a problem on a simulator. Which of the events/ steps cause of most problems associated with running process simulations? [4] CO3

3 **(a)** ***Answer the following:*** [4]

i. For fully developed turbulent flow, assuming all variables not mentioned are held constant, what is the effect of doubling the flowrate on the pressure drop? CO3

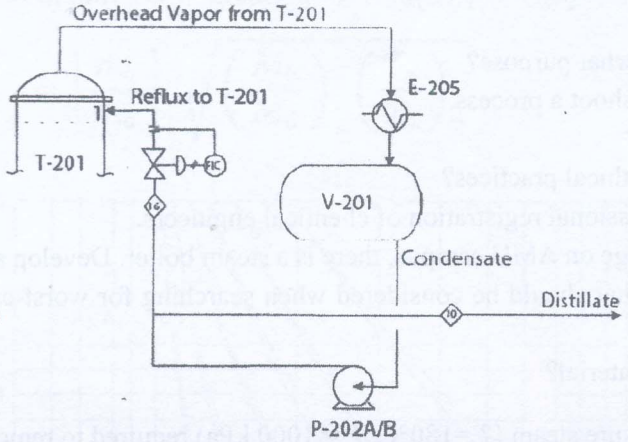
ii. Give any one reason for placing a specific fluid on the tube side of an S-T heat exchanger.

iii. State any one reason for requiring a high reflux ratio in a distillation column.

Why are some distillation columns run at vacuum?

Contd... 3

(b) Consider the flow of liquid from an overhead condenser on a distillation column to a reflux drum, as illustrated in the figure below. The liquid condensate flows from the heat exchanger, E-205, to the reflux drum, V-201. From the drum, the liquid flows to a pump, P-202, from which a portion (Stream 16) is returned to the distillation column, T-201, and the remainder (Stream 10) is sent to product storage. Assume that the amount returned to the column as reflux is set by a control valve, shown in the diagram. The amount of reflux is fixed in order to maintain the correct internal flows in the column and hence the product purity. [4] CO3

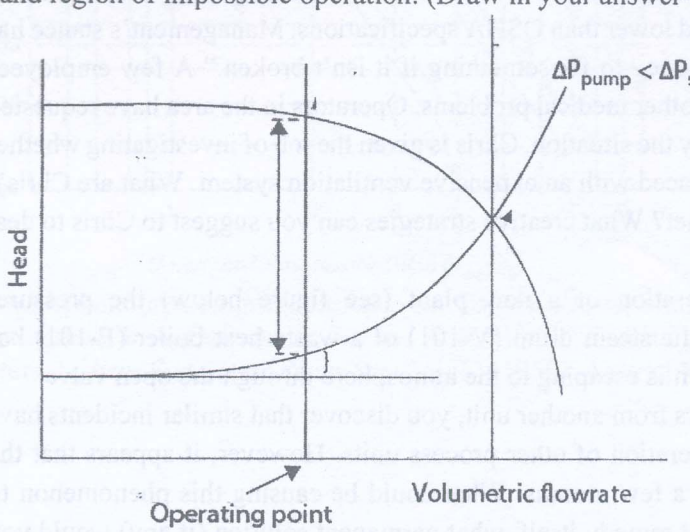


What could happen if there is an upset and there is an increase in the amount of liquid being sent to the reflux drum? How can the situation be controlled (Draw the control scheme)?

OR

(b') Mention how would you accomplish dynamic simulation of a compressor in a process simulator to regulate the output pressure? [4] CO2

(c) In the diagram given below, show the following: pump curve, system curve, pressure drop across pump, pressure drop across valve, pressure drop due to friction, maximum possible flowrate, and region of impossible operation. (Draw in your answer-book). [6] CO3



OR

Contd.... 4.

(c') A reboiler for a column is supplied with saturated steam (in shell) at a temperature of 145°C and reboils the bottom product (in tubes) that leaves the column at 122°C. It is desired to increase the boil-up rate by 15% from the design case. How can this change be accomplished? [6] CO3

4 **(a)** ***Answer <u>any five</u> the following:*** [10]

i. Comment on the following statement: "For highly exothermic reactions, some form of heat exchange should be integrated within the reactor." CO4 & CO5

ii. What is the corrosion allowance, why is it important?

iii. For a simple V-L knockout drum, give any one reason for using a 'vertically oriented' drum.

iv. Steam ejectors are used to serve what purpose?

v. Specify the three steps to troubleshoot a process.

vi. What is process debottlenecking?

vii. What is 'reflection in action' in ethical practices?

viii. Mention any two benefit of professional registration of chemical engineers.

ix. At the Dawakhana, Tibbiya College on AMU campus, there is a steam boiler. Develop any one possible accident scenarios that should be considered when searching for worst-case scenarios related to the boiler.

x. What is life cycle analysis of a material?

(b) Estimate the flowrate of medium pressure steam (T=180°C, P = 1000 kPa) required to remove an air leak of 300 kg/h into an overhead condenser system operating at 27.5 kPa pressure and 50°C using a single-stage steam ejector. You should assume that the steam and air stream will be partially condensed in a heat exchanger operated at an inlet pressure of 110 kPa (P). [5] CO4

(c) Answer <u>any two</u> of the following: [4+4]

i. Assume that the unit operations lab in your department must meet the process safety management standard. Choose two of the 13 components of PSM, and write a critical analysis of these aspects of lab operation. CO5

ii. In a unit where grain is steeped (soaked in hot water), sulphur dioxide is added directly to grain and water. Operators have long complained about sulphur dioxide fumes, citing runny noses, teary eyes, coughing, and headaches. The concentration has been checked many times and has always measured lower than OSHA specifications. Management's stance has always been, "Don't spend money to fix something if it isn't broken." A few employees have quit, citing allergies and other medical problems. Operators in the area have requested an engineering study to remedy the situation. Chris is given the job of investigating whether the exhaust fan should be replaced with an expensive ventilation system. What are Chris's obligations? Can they all be met? What creative strategies can you suggest to Chris to deal with this situation?

iii. During the start-up and operation of a new plant (see figure below) the pressure-relief/safety valve on top of the steam drum (V-101) of a waste heat boiler (E-101) has opened and low-pressure steam is escaping to the atmosphere through the open valve. Upon questioning the operators from another unit, you discover that similar incidents have occurred during the initial operation of other process units. However, it appears that the situation remedies itself after a few months. What could be causing this phenomenon to occur? If the situation does not remedy itself, what permanent solution (if any) would you suggest to fix the problem?

End of Questions

contd....5.

Attachment: Useful Expressions and Data

$$C_{BM} = C_p^o[B_1 + B_2 F_p F_M]$$

$$\log_{10} F_P = C_1 + C_2 \log_{10} P + C_3 (\log_{10} P)^2$$

$$COM = 0.280FCI + 2.73C_{OL} + 1.23(C_{UT} + C_{WT} + C_{RM})$$

$$COM_d = 0.180FCI + 2.73C_{OL} + 1.23(C_{UT} + C_{WT} + C_{RM})$$

$$\left[\frac{\dot{m}_b}{\dot{m}_a}\right]_2 = \left[\frac{\dot{m}_b}{\dot{m}_a}\right]_1 \sqrt{\left(\frac{M_b}{M_a}\right)_2 \left(\frac{T_a}{T_b}\right)_2}$$

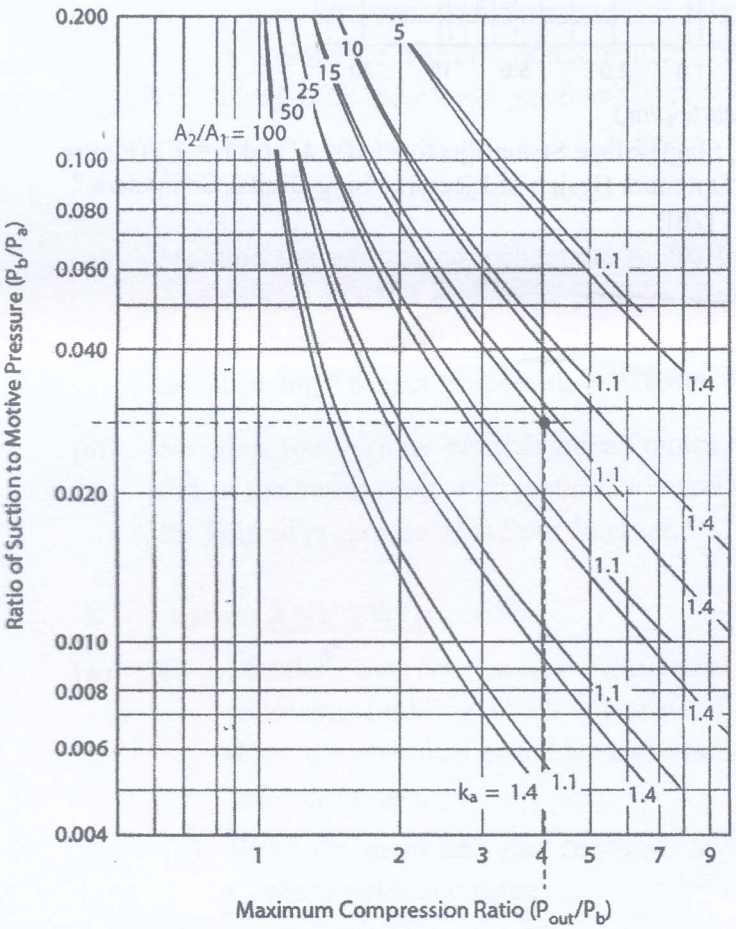


Figure A1 Maximum Compression Ratio for Constant-Area, Single-Stage Steam Ejectors ($M = M$ and $T = T$) (Figure Redrawn from DeFrate, L. A., and A. E. Hoerl, "Optimum Design of Ejectors Using Digital Computers." *Chem Eng Progr Symp Ser.* 21(55) (1959): 43–51 [20])

Contd....6.

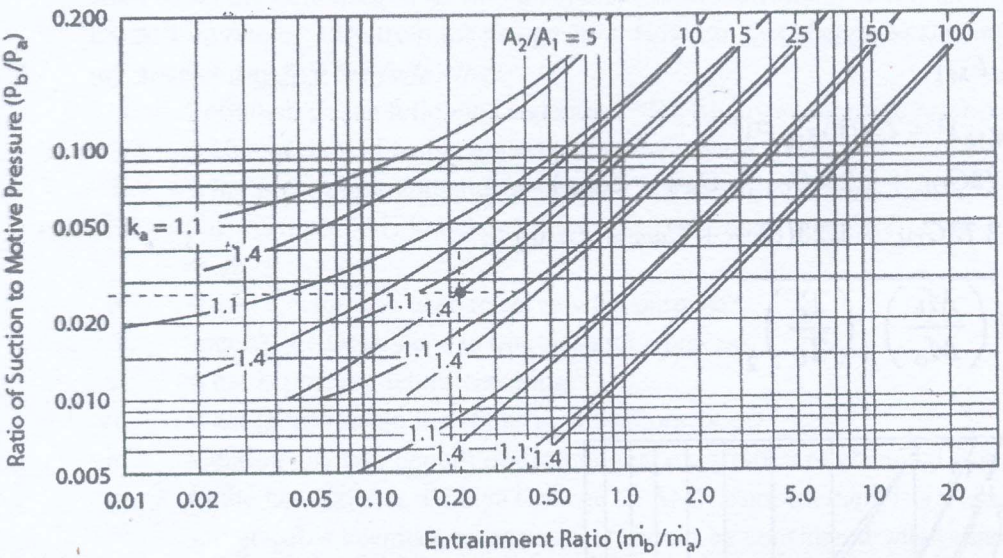


Figure A2 Entrainment Ratio for Constant-Area, Single-Stage Steam Ejectors ($M = M$ and $T = T$) (Figure Redrawn from DeFrate, L. A., and A. E. Hoerl, "Optimum Design of Ejectors Using Digital Computers." *Chem Eng Progr Symp Ser.* 21(55) (1959): 43–51 [20])

2023-24

B. TECH. (AUTUMN SEMESTER) EXAMINATION
PETROCHEMICAL ENGINEERING
PETROCHEMICAL TECHNOLGY II
PKC-4050

Maximum Marks: 60 **Credits: 04** **Duration: Two Hours**

Answer all questions.
Assume suitable data if missing.
Notations and symbols used have their usual meaning.
Use of Graph paper is allowed.

Q.No.		Question	CO	M.M.
1		Answer **ANY TWO:**		
(a)	(i)	Draw the chemical structure of **Acrylic Acid** and mention its uses. Mention the various petrochemical routes for Acrylic Acid production along with their main reaction(s).	(CO1)	[3.5]
	(ii)	For **Tertiary Butyl Alcohol (TBA)** production, compare the Oxirane process and Hydration process.	(CO1)	[3.5]
(b)		Mention the various petrochemical routes for **Acrylonitrile (ACN)** production. Justify why SOHIO process is preferred over other routes. Write the main and side reactions involved in SOHIO process, and describe the SOHIO process in details using a proper process flow diagram.	(CO1)	[07]
(c)		Mention the various petrochemical routes for **Maleic Anhydride** production. Select the better route with justification and describe the production process with the help of proper process flow diagram.	(CO1)	[07]
2		Answer **ANY TWO:**		
(a)	(i)	Mention the two **major** petrochemicals produced from each of the following building block elements: Benzene, Toluene & Xylene. Also, draw the chemical structure and one major application of the mentioned petrochemicals.	(CO2)	[02]
	(ii)	Write the main and side reactions involved in the **Phenol** production via Cumene oxidation route.	(CO2)	[02]
	(iii)	Briefly describe the Witten Process for **Dimethyl Terephthalate (DMT)** production.	(CO2)	[03]

Contd....2

(b)	Select the better petrochemical route with justification for **Linear Alkyl Benzene (LAB)** production and describe the production process with the help of proper process flow diagram.	(CO2)	[07]
(c)	Select a petrochemical route for **Phthalic Anhydride** production with proper reasoning and describe the production method with the help of process flow diagram.	(CO2)	[07]
3	Answer **ANY TWO:**		
(a)	(i) Write one major application of various types of **Polypropylene (PP)**. Compare the production technologies used for the various types of PP.	(CO3)	[03]
	(ii) Write the reaction for **Polyurethane (PU)** production. Differentiate between thermoplastic and thermoset PU, and briefly describe how reaction enables to control the properties of PU.	(CO3)	[04]
3(b)	Compare the various technologies available for **LDPE** production and justify which one is majorly used. Also, explain how the reaction chemistry enables to control the branching of LDPE.	(CO3)	[07]
3(c)	What are the different types of **Polystyrene (PS)** and their applications? Compare the technologies available for different types of PS production and describe the role of reaction chemistry in controlling the structure of PS.	(CO3)	[07]
4	Answer **ANY THREE:**		
(a)	(i) Differentiate between Commodity plastics and High performance plastics on the basis of their applications and properties.	(CO4)	[03]
	(ii) Describe the various types of polymers on the basis of stress-strain curve.	(CO4)	[03]
(b)	(i) Describe the reaction chemistry of **Nylon-6** polymerization.	(CO4)	[03]
	(ii) Mention the names of three majorly used **epoxy resins** and write the reaction for the synthesis of these mentioned epoxy resins.	(CO4)	[03]
(c)	Draw the structure of **Acrylonitrile-Butadiene-Styrene (ABS)** polymer along with its reaction chemistry. Describe a majorly used route for the production of standard ABS with the help of process flow diagram.	(CO4)	[06]
(d)	Explain the distinct properties of elastomers which differentiate them from rest of the polymers. Describe the production of **Styrene-Butadiene Rubber (SBR)** with the help of process flow diagram.	(CO4)	[06]

2023-24

B. TECH. (ODD SEMESTER) EXAMINATION
PETROCHEMICAL ENGINEERING
POLYMER SCIENCE AND TECHNOLOGY
PKC-4070

Maximum Marks: 60 **Credits: 04** **Duration: Two Hours**

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

Q.No.	Question	CO	M.M.
1(a)	What is the functionality of a monomer? How does it influence the structure of the polymer?	(CO1)	[05]
1(b)	When a monomer can undergo self-condensation polymerization? Write the reaction for example of self-condensation polymerization.	(CO1)	[05]
1(c)	For the determination of Viscosity Avg. Mol. Wt. (Mv) of Polystyrene sample was dissolved in Benzene solvent at different concentrations and flow times were measured with the help of an Ostwald viscometer at 30 °C. The following data was obtained;	(CO1)	[05]

	Data Set →	I	II	III	IV
1.	Concentration (g/cm^3)	0.008	0.006	0.004	0.002
2.	Mean Flow Time (s)	910	600	370	200
3.	Relative Viscosity(η_r)				
4.	Specific Viscosity(η_{sp})				
5	Reduced Viscosity (η_{red})				

*Note: The flow time of pure solvent (Benzene) at 30 °C is **100** seconds.*

Calculate the values of Relative Viscosity(η_r), Specific Viscosity(η_{sp}) and Reduced Viscosity (η_{red}) in tabular form for every set of data.

2(a)	What are the assumptions made for the development of Step Polymerization Kinetics? Explain why externally catalyzed step polymerization is more efficient than self-catalyzed reaction.	(CO2)	[05]

contd....2.

OR

2(a') Calculate the feed ratio (r) of Adipic acid (AA) and Hexamethylene diamine (HMD) that should be used to get Nylon 6,6 of molecular weight 12000 at p= 99.5 and 99.9 % conversion. (CO2) [05]

2(b) Derive the following relationship for step polymerization reaction; (CO2) [05]
$Rp = K.K_3 [COOH]. [HA]. [OH]$

OR

2(b') What would be the number average and weight average molecular weight of a sample of polyethylene oligomer that consists of 10 mol of hexamer and 8 mol of pentamer? (CO2) [05]

2(c) Explain the GEL effect in bulk polymerization. Suggest methods to avoid this situation. (CO2) [05]

OR

2(c') What would be the number average and weight average molecular weight of a sample of polypropylene oligomer that consists of 10 mol of hexamer and 8 mol of pentamer? (CO2) [05]

3(a) What do you mean by the term "Viscoelastic"? Drive the expression for Maxwell's model of Viscoelasticity. (CO3) [05]

OR

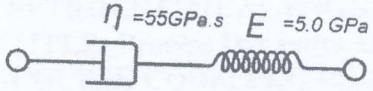
3(a') Write down the equation for "Shear Stress Profile" and "Velocity Profile" for the flow of polymer melt in a circular capillary along with the description of nomenclature. (CO3) [05]

3(b) Explain the viscometric plot for polymer. Also, explain the effect of various processing parameters over the viscosity of the polymer melt with the help of suitable curves. (CO3) [05]

OR

3(b') Name the viscoelastic model represented by the series combination of dashpot and spring, as shown in the figure below. Also, calculate the relaxation time (λ) for this model. (CO3) [05]

Contd ... 3.



3(c) Explain the construction, working, and governing equations for the capillary rheometer. [05]

OR

3(c') How polymer processing is influenced by the rheological behavior of polymer melt? (CO3) [05]

4(a) Drive the expression for Screw and Die Characteristic Curves (SCC and DCC) and explain the effect of the following processing parameters; (CO4) [05]

1. Screw RPM
2. Melt Temperature
3. Diameter of die orifice

4(b) Draw a neat and clean diagram of the extrusion pipe plant and explain the construction and working principle. (CO4) [05]

4(c) Differentiate between; (CO4) [05]

(i). Rotational molding and Blow Molding

(ii). Injection Molding and Extrusion process