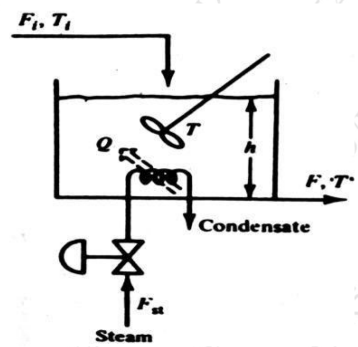
12/11/2024 CHEMICAL ENGG. SEM-VII C SCHEME IPDC QP CODE: 10067002

Time: 3 Hours **Total marks: 80**

N.B.:
1) Question-1 is compulsory. Answer any three questions from remaining
2) Assume data if necessary and specify the assumptions clearly
3) Draw neat sketches wherever required
4) Answer to the sub-questions of an individual question should be grouped and written together i.e. one below the other

Q.1) a) Draw feedback control loop for temperature control of stirred tank heating system shown below, classify the variables and make control pair **(5)**



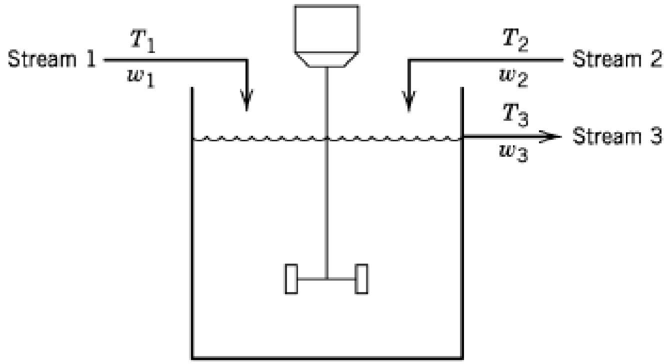
b) State the number of roots located on the right half of s-plane for the characteristic equation $s^3+4s^2+s+16=0$ **(5)**

c) Consider a transfer function : $G(S) = \frac{Y(s)}{U(s)} = \frac{3}{10s+1}$ **(5)**

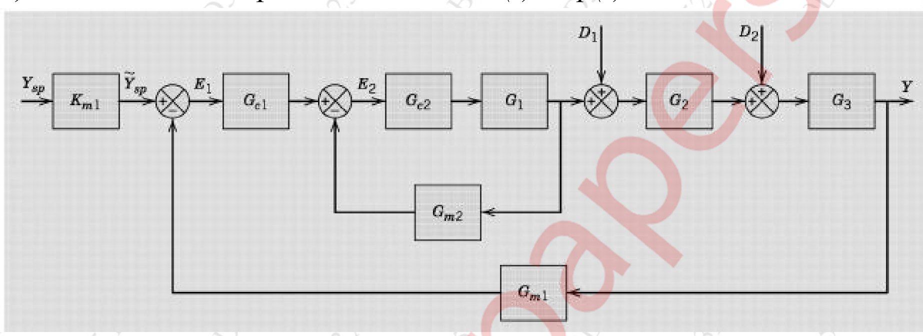
What is the steady state gain?
What is the time constant?
If U(s)=2/s, what is the value of the output Y(t) when $t \rightarrow \infty$?

d) Draw a standard block diagram and write transfer function for Servo and Regulatory problem. **(5)**

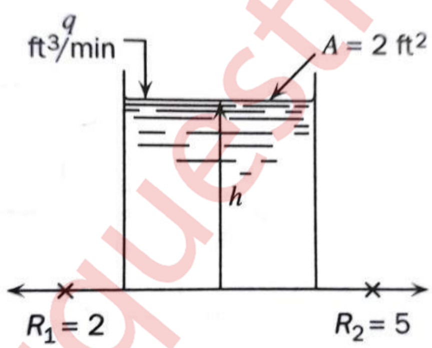
Q.2) a) A perfectly stirred, constant-volume tank has two input streams, both consisting of the same liquid. The temperature and flow rate of each of the streams can vary with time. Derive a dynamic model that will describe transient operation. Also perform degrees of freedom analysis assuming that both Streams 1 and 2 come from upstream units (i.e., their flow rates and temperatures are known functsions of time). Notes: wi denotes mass flow rate for stream i. Liquid properties are constant (not functions of temperature) **(10)**



b) Obtain closed loop transfer function *Y(s)/ Ysp(s)?* **(10)**



Q.3) a) Derive the transfer function H/Q for the liquid level system shown in figure. The resistances are linear. H and Q are deviation variables. Show clearly how you derive the transfer function. You are expected to give numerical values in the transfer function. **(10)**



b) A heater for a semiconductor wafer has first-order dynamics, that is, the transfer function relating changes in temperature T to changes in the heater input power level P is **(10)**

$$\frac{T'(s)}{P'(s)} = \frac{K}{\tau s + 1}$$

where K has units [°C/Kw] and T has units [min]. The process is at steady state when an engineer changes the power input stepwise from 1 to 1.5 Kw. She notes the following:

i. The process temperature initially is 80 °C.
ii. Four minutes after changing the power input, the temperature is 230 °C.
iii. Thirty minutes later the temperature is 280 °C.

What are K and τ in the process transfer function?

Q.4) a) Consider the following transfer function of a process: **(10)**

$$Gp(s) = \frac{10e^{-1.5\,s}}{(4s^2 + 4s + 1)}$$

Design a PI controller, for a negative, feedback loop of the process, based on the Zeigler and Nichols tuning rules

b) The dynamic behavior of a pressure sensor/transmitter can be expressed as a first-order transfer function (in deviation variables) that relates the measured value P_m to the actual pressure, P: **(10)**

$$\frac{P_m(s)}{P(s)} = \frac{1}{30s+1}$$

Both $P_m(s)$ and $P(s)$ have units of psi and the time constant has units of seconds. Suppose that an alarm will sound if P_m exceeds 45 psi. If the process is initially at steady state, and then P step changes from 35 to 50 psi at 1:10PM, at what time will the alarm sound?

Q.5) a) A unity feedback system has $G(s) = \frac{2(s+0.25)}{s^2(s+1)(s+0.5)}$. From bode plot, find GM, PM, phase cross over frequency, and gain cross over frequency? Also Comment on stability **(15)**

b) Consider a process, Gp=0.5/(-s+1) that is open-loop unstable. If Gv=Gm=1, determine whether a proportional controller can stabilize the closed loop system? **(5)**

Q.6) a) Write short note on static performance characteristics of instruments **(10)**

b) Write short note on control valve characteristics **(10)**

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