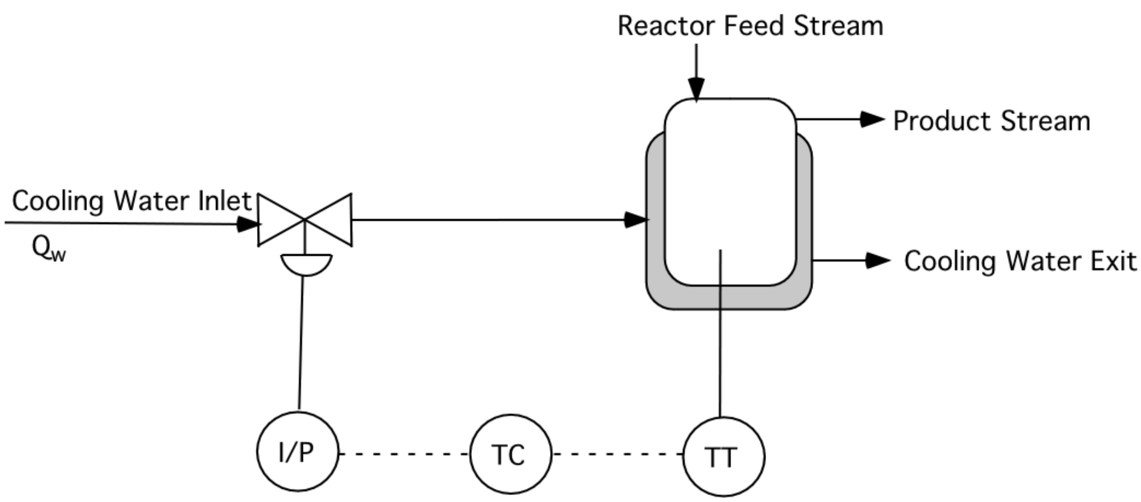
Name______________________________ Take Home Quiz

1. (10 pts) Cooling water flows through a jacket to control the temperature of a reactor, as shown below. The transfer function relating the reactor temperature T to the flow rate of cooling water through the jacket (Q_w) is:

$$\frac{T'(s)}{Q_w'(s)} = \frac{-0.7}{(s+1)(2s-1)} \quad °F/gpm$$

where the time constants are in minutes. The valve on the cooling water inlet fails in the open position (air-to-close), and passes 360 gpm of water when completely open. You may assume that the pressure drop across the valve is constant, that valve dynamics are negligible, and that the valve is linear. The temperature transmitter has a range of 200-400°F and requires about 0.5 minutes for a reading to reach its final value (5τ). The output from the transmitter is a 4-20 mA signal to the reverse-acting controller. The proportional-only controller outputs a current signal, which is converted to pressure in a standard I/P transducer (4-20 mA, 3-15 psig). Sketch a block diagram for the system and determine the transfer function for each of the blocks, including units.

Mario Diaz notices that the process is unstable, but claims that stable operation can be achieved with the feedback control loop shown and a proportional-only controller. What range of values of K_c (if any) will make this process stable?



Multiple Choice (Circle One)

a) $1.23 < K_c < 6.52$

b) $-10.2 < K_c < 10.2$

c) $0.79 < K_c < 8.29$

d) None of the above

2. (10 pts) A reversible chemical reaction, A->B and B->A, occurs in an isothermal continuous stirred-tank reactor. The rate expressions for the forward and reverse reactions are:

$r_1 = k_1 C_A$
$r_2 = k_2 C_B$

where the rate constants have the following temperature dependence (note that k_1 has **-5000** and k_2 has **-5500** in the exponent):

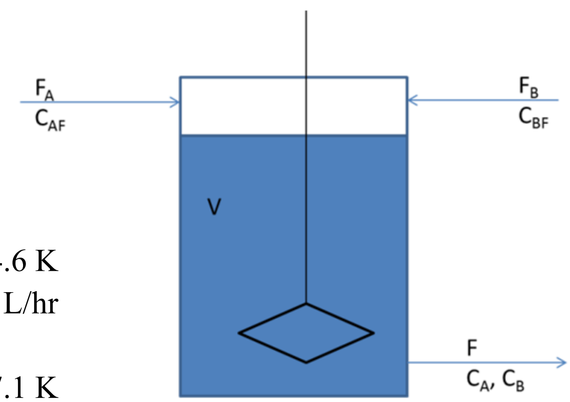
$k_1 = 3.0\text{x}10^6 \exp(\mathbf{-5000}/T)$
$k_2 = 6.0\text{x}10^6 \exp(\mathbf{-5500}/T)$

Each rate constant has units of hr^{-1} and T is in Kelvin. Determine the optimum values of temperature T (K) and flow rate F_B (L/hr) that maximize the steady-state production rate of component B that is produced in the reactor, not just flowing out of the reactor. The allowable values are

$0 \le F_B \le 200$
$300 \le T \le 500$

Available information
i) You can use the following as a template:
http://apmonitor.com/online/view_pass.php?f=hw19.14.apm
ii) The reactor is perfectly mixed.
iii) The volume of liquid, V, is maintained constant.
iv) The following parameters are kept constant at the indicated numerical values:

$V = 200$ L
$F_A = 150$ L/hr
$C_{AF} = 0.3$ mol A/L
$C_{BF} = 0.3$ mol B/L



Multiple Choice (Circle One)

a) Temperature (T) = 404.6 K
Flow rate B (F_B) = 0.0 L/hr

b) Temperature (T) = 367.1 K
Flow rate B (F_B) = 200.0 L/hr

c) Temperature (T) = 311.3 K
Flow rate B (F_B) = 200.0 L/hr

d) Infeasible, No solution

e) None of the above