1. The reactor shown below is used to conduct an exothermic reaction (A=>B). There is a valve at the reactor outlet that can be used to divert some of the exit stream, in order to pre-heat the reactor inlet. There is a controller attached to the reactor, in order to maintain the reactor temperature. Based on this scenario, answer the following questions.

![Diagram of reactor with recycle flow and controller](image)

a) What is the gain between the recycle flowrate and the concentration of A leaving the reactor (C_A)?

Circle: Positive Negative Neutral

b) What is the gain (+ or -) between the inlet concentration (C_Ai) and the concentration of A leaving the reactor (C_A)?

Circle: Positive Negative Neutral

c) What is the gain (+ or -) between the recycle flowrate and the reactor temperature (T)?

Circle: Positive Negative Neutral

d) What is the gain (+ or -) between the inlet flowrate (F_i) and the concentration of B leaving the reactor (C_B)?

Circle: Positive Negative Neutral

e) What is the gain (+ or -) between the inlet flowrate (F_i) and the reactor temperature (T)?

Circle: Positive Negative Neutral

e) Should the valve be designed as fail-open or fail-closed?

Circle: Fail-open Fail-close

f) Is the control strategy shown in the diagram feedforward or feedback?

Circle: Feedforward Feedback
2. The fermentation reactor shown below is very sensitive to the pH. Thus, there are two control loops (labeled “1” and “2”) to control the pH. The nutrient solution is naturally acidic, but if it is too acidic, then a basic buffer is added (via loop 1). Also, if the solution in the tank becomes too acidic, then a basic buffer can be added (via loop 2). The worst-case scenario is if the solution in the reactor becomes too acidic. Based on this scenario, answer the following questions.

a) What is the gain between the caustic flowrate and the pH of the tank?
   Circle: Positive   Negative   Neutral

b) What is the gain between the nutrient flowrate and the pH of the tank?
   Circle: Positive   Negative   Neutral

c) Should the valve be designed as air-to-open or air-to-close?
   Circle: air-to-open   air-to-close

d) Is control loop #1 feedforward or feedback?
   Circle: Feedforward   Feedback

e) Is control loop #2 feedforward or feedback?
   Circle: Feedforward   Feedback

f) What is the gain between the caustic flowrate and the volume of liquid in the tank?
   Circle: Positive   Negative   Neutral
3. Heating oil (with an adjustable flowrate of F₂) is used to maintain the temperature in a fermentation unit using a feedback control strategy. The cold feed broth sporadically enters the fermentation tank with a flowrate of F₁. The exit flowrate of the fermented broth (F₃) cannot be adjusted, but its temperature can be measured. Which block diagram corresponds to this process? **(circle answer)**

![Diagram Options]

(A)

(B)

(C)

(D)

What is the **sign of the gain** between F₂ and the temperature (T) of the exit stream?

What is the **sign of the gain** between F₁ and the temperature (T) of the exit stream?

If a feedforward control strategy is used instead, what would change in the control loop?

- manipulated variable
- measured variable
4. **Which of the following statements are FALSE?**

a) Feedback and feedforward control both require a measured variable.

b) The process variable to be controlled is measured in feedback control.

c) Feedforward control can provide perfect control; that is, the output can be kept at its desired value, even with an imperfect process model or disturbances.

d) Feedback control can be combined with feedforward control to reduce drift in the setpoint.

5. **Chapter 1, problem #8**

6. **Chapter 1, problem #10**