BONUS OP

Chemical Engineering Plebe Majors Fair

22 OCT 2025 from ~1220 to ~1350
Thayer Hall Room 336, 368, or 370[1]

30 minutes = 5 points[2]
Max 1.5 hours (15 points)

Notes:
1. We will only occupy one room.
2. Sign in and out on the provided roster with time in and time out. Interact with prospective cadets and answer questions. Stay active. Try not to congregate in "friends" clusters.

CH365 Chemical Engineering Thermodynamics

Lesson 23
Calculation of Entropy and Entropy Changes for an Ideal Gas

Summary of Section 5.4

There exists a property called entropy S, which is an intrinsic property of a system, functionally related to the measurable coordinates characterizing the system. For a reversible process, changes in this property are given by Eq. 5.1.

$$dS^t = \frac{dQ_{rev}}{T} \qquad \text{Eq. 5.1} \qquad \text{(Axiom to 2}^{\text{nd}}\text{ Law)}$$

The change in entropy for any system undergoing a finite reversible process is:

$$\Delta S^t = \int \frac{dQ_{rev}}{T} \qquad \text{Integral of Eq. 5.1}$$

When a system undergoes an irreversible process between two equilibrium states, the irreversible path cannot be directly integrated. The entropy change of the system is evaluated by integrating Eq. 5.1 along an arbitrarily chosen reversible process that accomplishes the same change of state as the actual process. Because entropy is a state function, the entropy changes of the irreversible and reversible processes are identical.

Independent of Path – State Function

Entropy Changes for an Ideal Gas

Integrated Forms

$$ICPS = \int_{T_0}^{T} \frac{C_P^{ig}}{R}\frac{dT}{T} = A \cdot \ln\frac{T}{T_0} + \left[B + \left(C + \frac{D}{T_0^2 T^2}\right)\cdot\left(\frac{T+T_0}{2}\right)\right]\cdot(T - T_0)$$

Eq. 5.11

$$MCPS = \frac{\langle C_P^{ig}\rangle_S}{R} = A + \left[B + \left(C + \frac{D}{T_0^2 T^2}\right)\cdot\left(\frac{T+T_0}{2}\right)\right]\cdot\left(\frac{T - T_0}{\ln(T/T_0)}\right)$$

Eq. 5.13

where $\langle C_P^{ig}\rangle_S = \dfrac{\int_{T_0}^{T} C_P^{ig} dT / T}{\ln(T/T_0)}$

Eq. 5.12

$$\frac{\Delta S}{R} = \int_{T_0}^{T} \frac{C_P^{ig}}{R}\frac{dT}{T} - \ln\frac{P}{P_0}$$

Eq. 5.10

$$\frac{\Delta S}{R} = ICPS - \ln\frac{P}{P_0}$$

$$\frac{\Delta S}{R} = MCPS \cdot \ln\left(\frac{T}{T_0}\right) - \ln\frac{P}{P_0}$$

Eq. 5.14

Example 5.4

Methane gas at 550 K and 5 bar undergoes a reversible adiabatic expansion to 1 bar. Assuming methane to be an ideal gas at these conditions, find its final temperature.

Example 5.4

Questions

Homework

Problem 5.8

With respect to 1 kg of liquid water:

(a) Initially at 0 °C, it is heated to 100 °C by contact with a heat reservoir at 100 °C. What is the entropy change of the water? What is the entropy change of the heat reservoir? What is ΔS_{total}?

(b) Initially at 0 °C, it is first heated to 50 °C by contact with a heat reservoir at 50 °C, and then heated to 100 °C by contact with a heat reservoir at 100 °C. What is ΔS_{total}?

(c) Explain how the water might be heated from 0 to 100 °C so that $\Delta S_{total} = 0$.

For liquid water: $C_{P,water} = 4.184 \frac{kJ}{kg \cdot C} = 4.184 \frac{kJ}{kg \cdot K}$

Problem 5.10

An ideal gas, CP = (7/2)R, is heated in a steady-flow heat exchanger from 70 deg C to 190 deg C by another stream of the same gas, which enters at 320 deg C. The flow rates of the two streams are the same, and heat losses from the exchanger are negligible.

(a) Calculate the molar entropy changes of the two gas streams for both parallel and countercurrent flow in the exchanger.

(b) What is ΔS_{total} in each case?

(c) Repeat parts (a) and (b) for countercurrent flow if the heating stream enters at 200 deg C.

Assume pressure drop is negligible. Not a good assumption but needed.

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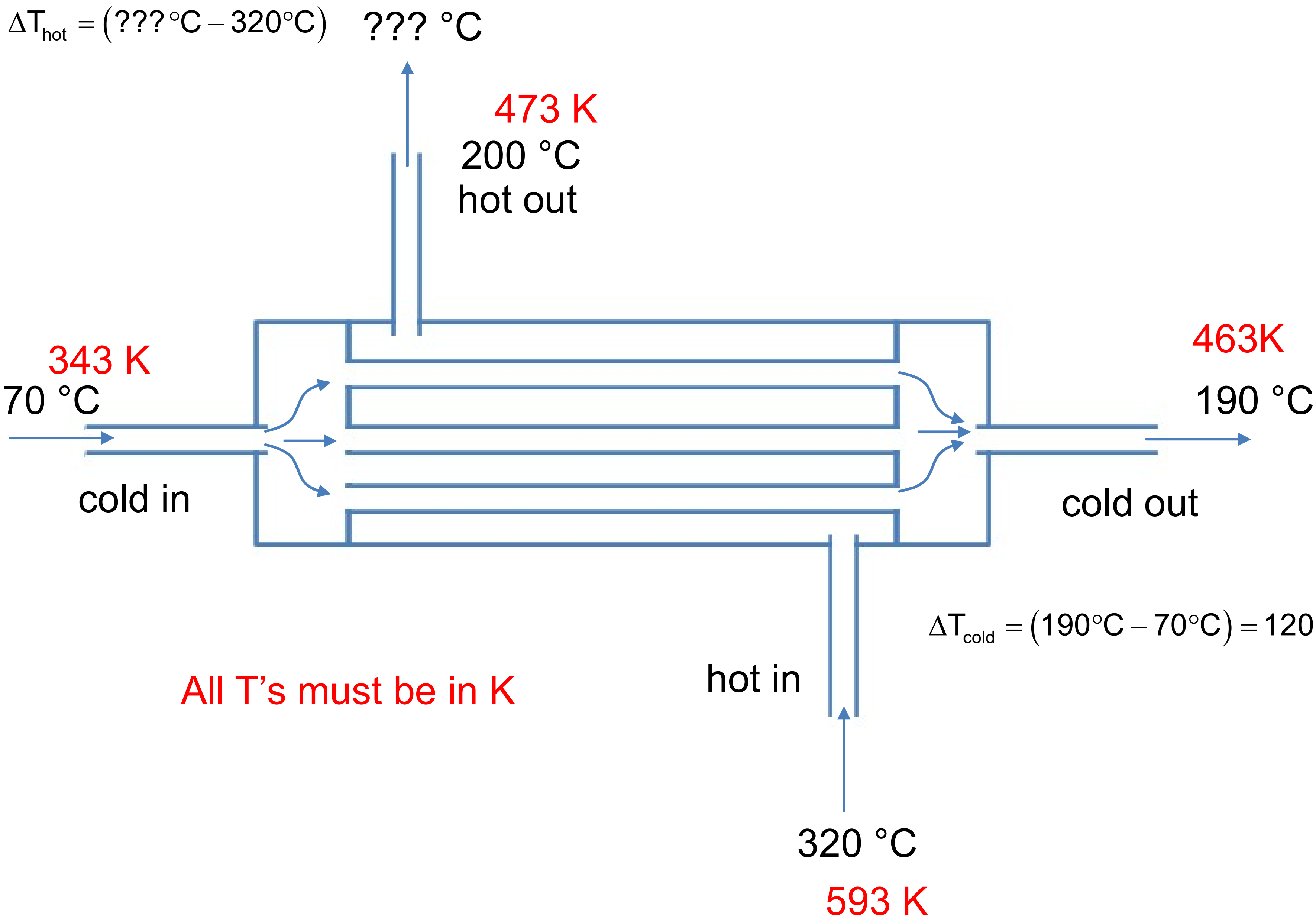
Part (a)

Counter-current

$\Delta T_{hot} = (???\,°C - 320°C)$



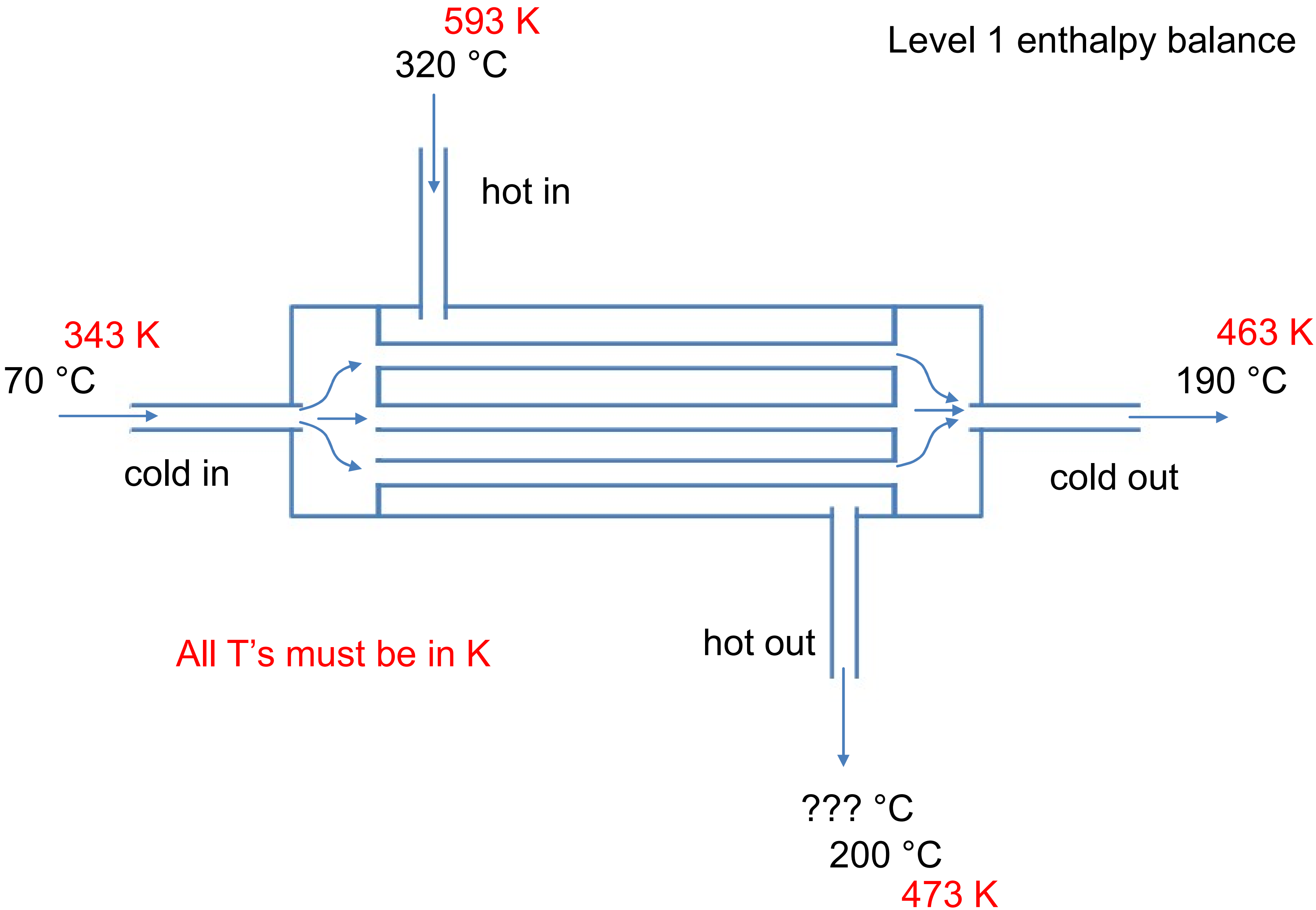
$\Delta T_{cold} = (190°C - 70°C) = 120°C$

All T's must be in K

Part (a)

Co-current

Level 1 enthalpy balance

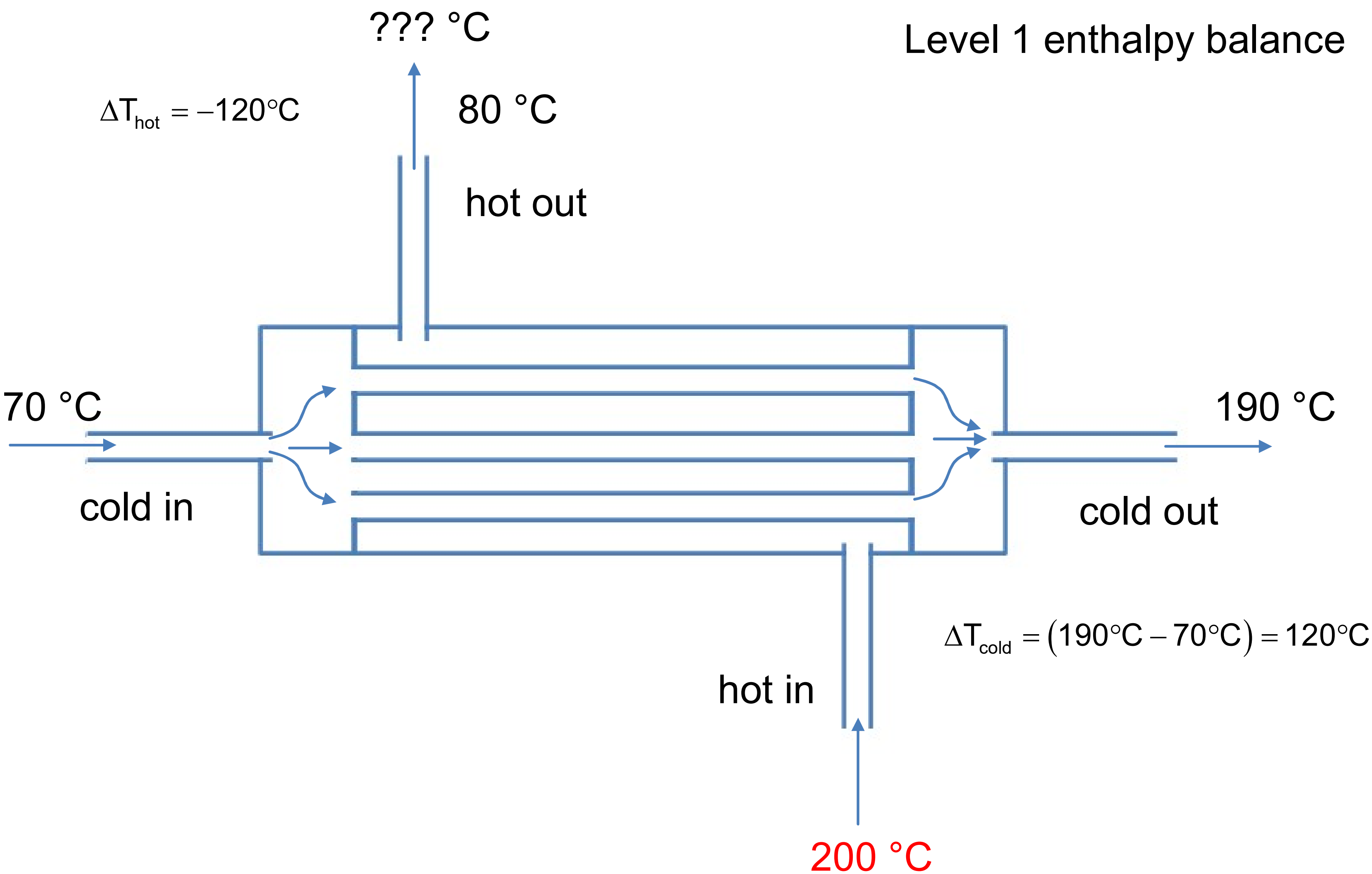


All T's must be in K

Part (c)

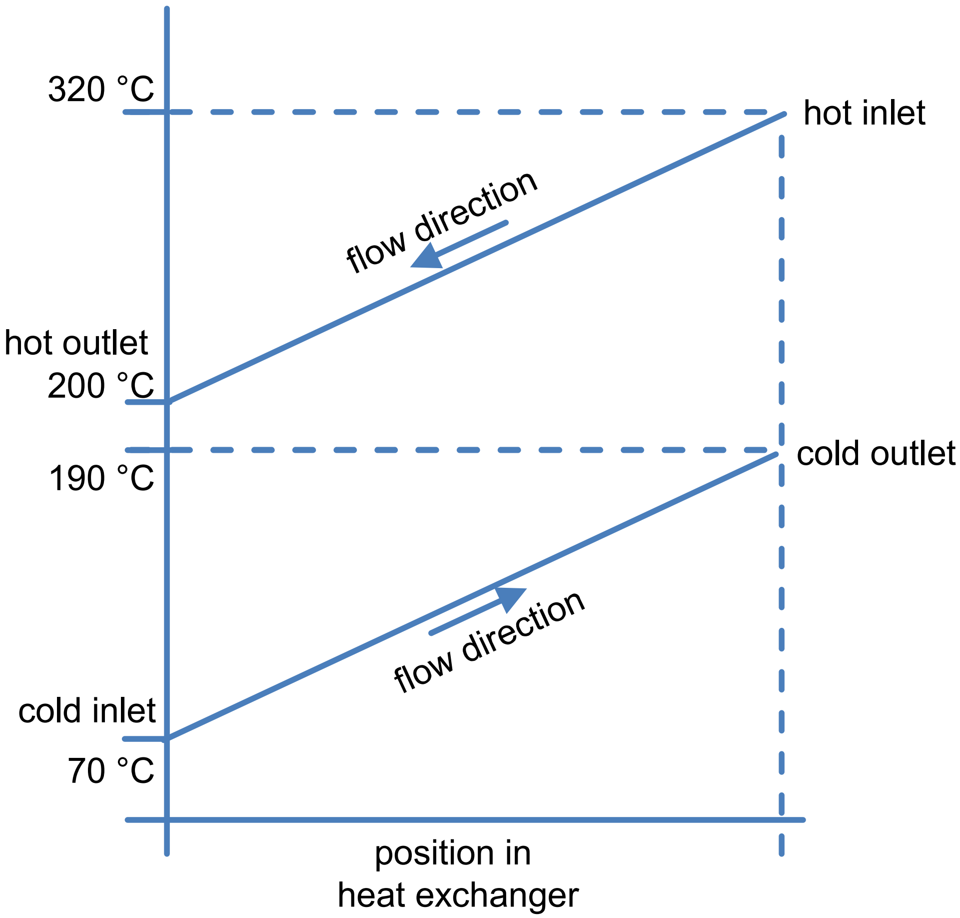
Counter-current

Level 1 enthalpy balance



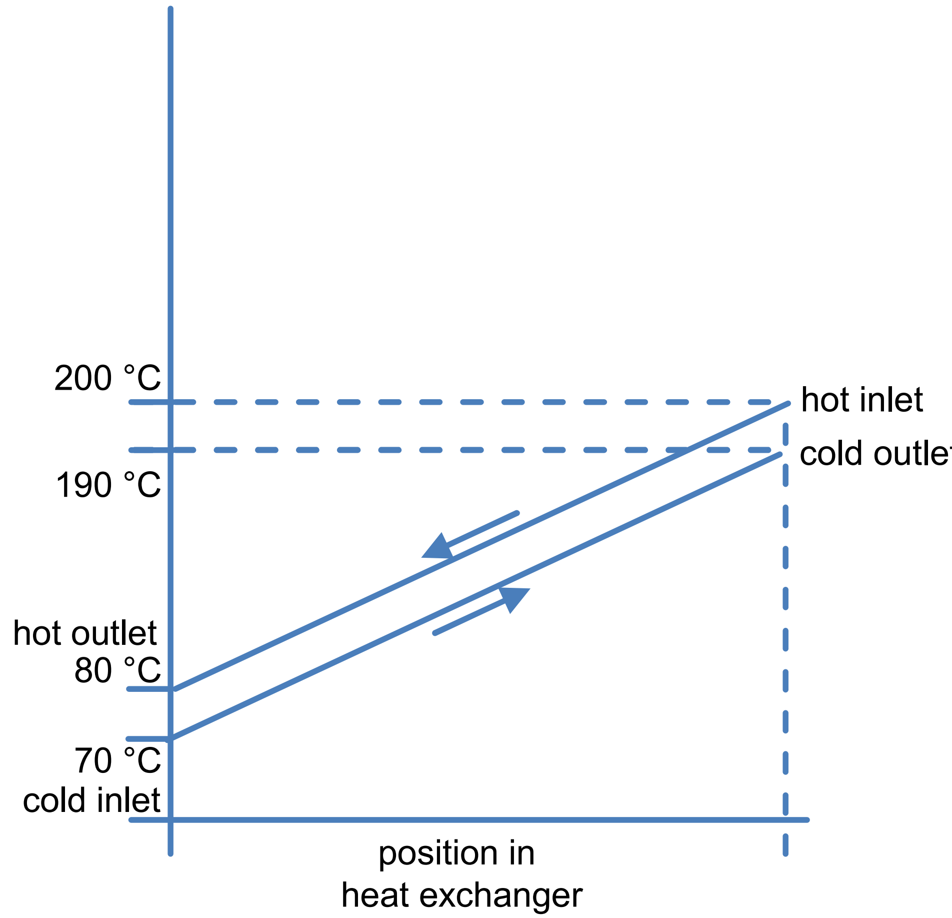
Counter-current Flow

parts (a), (b)



$$\Delta S_{total} = 2.149 \frac{J}{mol \cdot K}$$

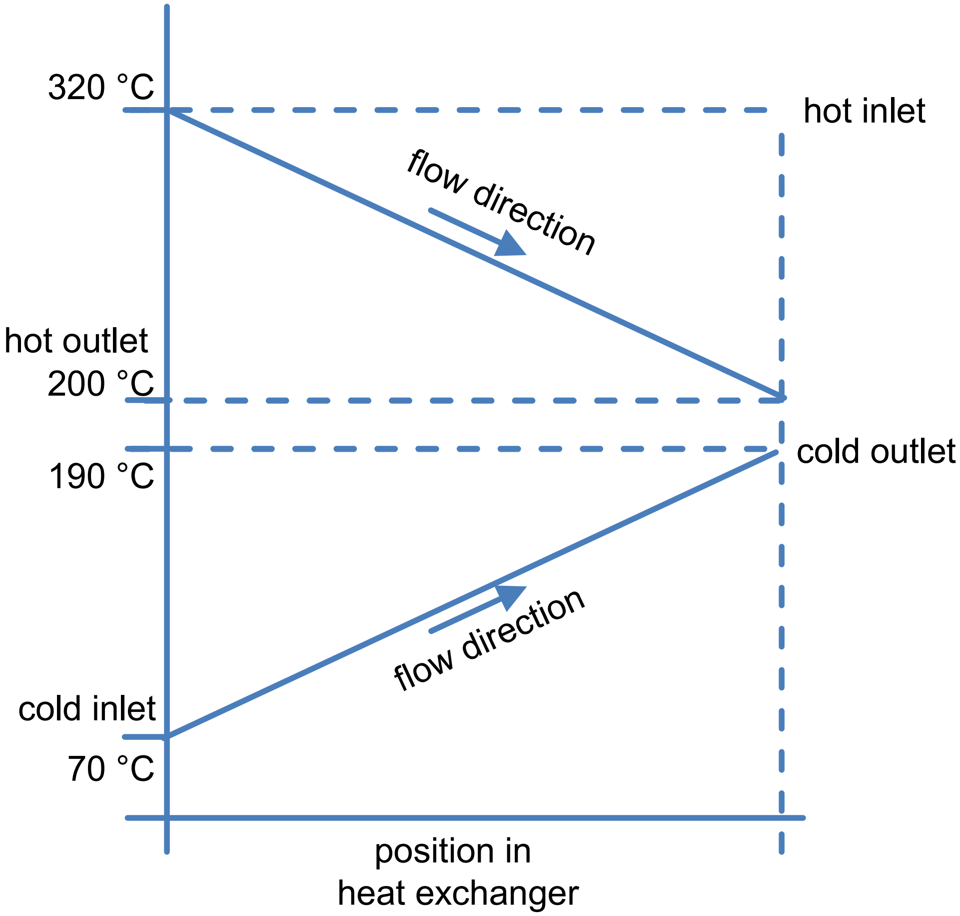
part (c)



$$\Delta S_{total} = 0.214 \frac{J}{mol \cdot K}$$

Co-current Flow

parts (a), (b)



$$\Delta S_{total} = 2.149 \frac{J}{mol \cdot K}$$

part (c)

not part of problem