Name ____

Wednesday, February 28th

ECHE 363 – Thermodynamics of Chemical Systems
Midterm #1

Rules:

- 75 minutes total time. Once time is up, put aside answer sheets.
- Be sure to show all work to obtain maximum credit. This includes showing and simplifying any mass/mole, 1st Law, and 2nd Law balances that are needed to solve each problem.
- Closed book and no notes.
- Write your name on every page.
- Please only write on the front side of each page. Ask for additional paper if necessary.

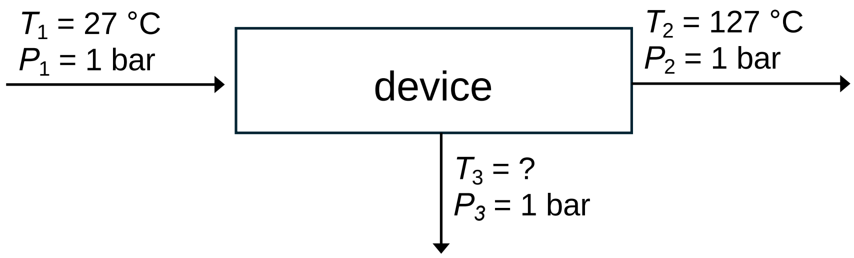
Name ____

For instructor use only:

Problem 1 / 25	
Problem 2 / 40	
Problem 3 / 35	
Total / 100 points	

Name ____

1. (25 points) Nitrogen gas at 27 °C in "stream 1" flows into a well-insulated device operating at steady state. There is no shaft work. Two-thirds of the nitrogen, by moles, exits at 127 °C and 1 bar in "stream 2". The remainder of the nitrogen exit through "stream 3" at an unknown temperature and 1 bar. Find the temperature of the nitrogen in the "stream 3" outlet. Assume ideal gas behavior, where nitrogen has $c_{p,m}$ = 29.1 J/mol-K.



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2. (40 points) Steam is fed to an adiabatic turbine at 4 MPa and 500 °C. It exits at 0.2 MPa. Assuming that the process occurs at steady state, what is the maximum possible work (per kg of steam) that can be extracted from the turbine?
   Hint: remember to determine the phase of both the input and output water streams.

Name ____

Name ____

Name ____

3. (35 points) One mole of an ideal gas contained within a piston–cylinder assembly has an initial pressure of $P_1 = 5$ bar and initial temperature of $T_1 = 500$ K. It undergoes a <u>reversible expansion</u> until it reaches a final pressure of $P_2 = 1$ bar and final temperature of $T_2 = 300$ K. The expansion is not adiabatic and thus <u>heat transfer cannot be neglected</u>. The surroundings have a temperature of $T_{surr} = 300$ K. The fluid has a constant-pressure heat capacity of:

   $c_{p,m}/R = A + BT$, where $A = 3.5$ and $B = 0.02\ \mathrm{K}^{-1}$

   For the process described above, calculate: W, Q, ΔS_{sys}, ΔS_{surr}, ΔS_{univ}.

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