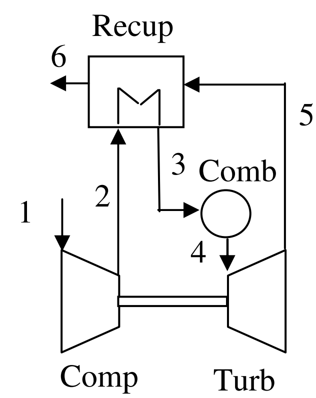
Thermo 1. A recuperated (regenerated) Brayton cycle engine is shown schematically in the diagram below.

a) Sketch the corresponding ideal T-s diagram and label the state points on it.
b) If the cycle is ideal (perfect gas, isentropic compression/expansion, isobaric heat transfer), show that the thermodynamic cycle efficiency is a function solely of T1 and T3.
c) For very small pressure ratio (near unity), show that the ideal recuperated Brayton cycle efficiency approaches the Carnot efficiency.
d) As pressure ratio is increased above unity, describe qualitatively the change in specific work. You may use T-s sketches to illustrate this if desired. What is the value of specific work at the limit of part c)?
e) Relate your findings to real recuperated engines, which typically have pressure ratios around 4. Write one or two paragraphs describing the effect of irreversibilities associated with compression, expansion, friction and heat loss on maximum efficiency, and the trade-offs made in operating with 4:1 pressure ratio.



Thermo 2. A chamber contains one kmol of N_2 gas at 300K. The gas is suddenly heated to a very high temperature and increased pressure (for example, by using a shock tube). The gas then reaches equilibrium adiabatically, the final state being 4000 K and 10 atm.

a) Find the mole fractions of N and N_2 atoms at the final state.
b) Estimate the temperature of the N2 immediately after the sudden heating process (before the partial dissociation of N_2 into a mixture of N_2 and N).

For both parts, you may use approximations if you justify them.

Given data:

For N_2, assume <u>constant</u> molar specific heat: $\overline{C}_{p,N_2} = 37.7 \frac{KJ}{Kmol \cdot K}$

For N, <u>calculate</u> the molar specific heat if needed, given R_u=8.314 KJ/Kmol K. Hint: what is the specific heat ratio of a monatomic gas?
Heat of formation for N is 473,000 KJ/Kmol