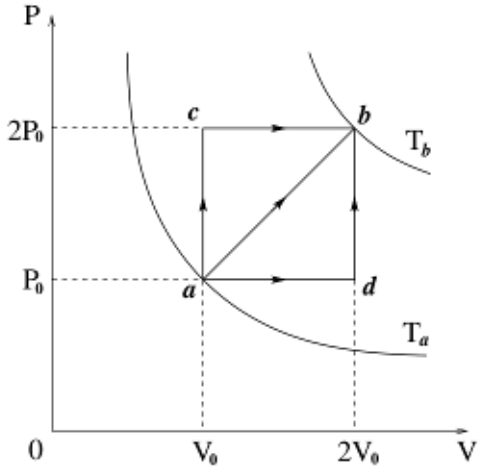
Thermodynamics

Do two of the following three problems, each on a separate sheet (or sheets). Staple together the sheets for each problem, if using multiple sheets, but do not staple all problems together. Write at the top of the first sheet of each problem your name, subject, and problem number.

Problem 1

A monatomic ideal gas is taken from point a to point b along three paths: $a-c-b$, $a-d-b$, and $a-b$. Calculate the heat supplied to the gas in each of the three processes. Express your answer in terms of the number of gas atoms N, Boltzmann constant k, and temperature T_a.



Problem 2

During a portion of the Carnot cycle, a dilute gas of diatomic nitrogen is compressed slowly at constant temperature, $T = 280$ K. The initial volume of the gas is 0.3 m^3 and the final volume of the gas is 0.1 m^3. Assume that the gas consists of 3×10^{24} molecules.

a) What is the change in multiplicity of the gas? Express the factor by which the multiplicity changes as 10 raised to some power.

b) What is the change in entropy of the gas?

c) How much energy was transferred to the environment through heating or cooling? Specify whether the energy of the environment decreased or increased.

Problem 3

Consider a model for a space station as a cyllinder of radius R_0 spinning around its axis. The angular velocity Ω is such that the acceleration at the rim of the cyllinder is g, providing a simulation of the Earth's gravity. The cyllinder is filled with air of constant temperature T throughout the station. Calculate the ratio of pressures at the center and at the rim of the cyllinder, P_c/P_0.
Suggestion: Consider the kinetic energies of the air molecules which rotate together with the cyllinder and treat it as a problem of gas in a gravitational field.