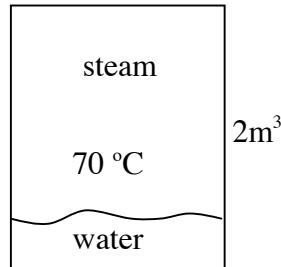


(Please write in pen rather than in pencil. No regrading for quizzes written in pencil.)

Problem 1 (10 pts + 2 pts extra credit)

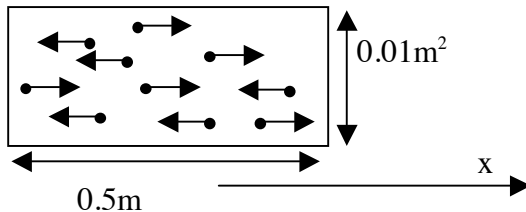


There are 11 mol of liquid water in equilibrium with steam in the closed container shown in the figure, of volume 2m³, at temperature 70°C. Assume the steam behaves as an ideal gas, and the volume occupied by the liquid can be ignored since it is very small.

The saturated vapor pressure of water at 70 °C is 3.12x10⁴N/m², at 80 °C it is 4.73x10⁴N/m². The latent heat of vaporization of water is 2.26x10⁶J/kg. Assume the specific heat of water and steam in this temperature range is the same, 3000J/kg °C. The molecular weight of water is 18. The gas constant is R=8.314J/mol K.

- How many mol of vapor (steam) are there in the container at 70°C?
- The temperature of the system is raised to 80°C. Does all the liquid evaporate or only part?
- If you answered "part" in (b), find how many mol of liquid remain. If you answered "all" in (b), find the pressure of the steam.
- How much heat was added to the system (in J) to bring it from 70°C to 80°C? Your answer may be approximate (within 10%).

Problem 2 (10 pts)



The container in the figure has length 0.5 m in the x direction, and cross-sectional area 0.01m² perpendicular to the x direction . It contains 1.2x10²⁴ He atoms. Assume initially all the atoms are moving horizontally in the + or - x direction, with the same number going right and left, each atom with speed 500m/s. Assume one can ignore collisions between the atoms, and that the atoms collide elastically with the walls.

The mass of the He atom is 4u, 1u=1.66x10⁻²⁷kg. R=8.314J/mol K. N_A=6.02x10²³.

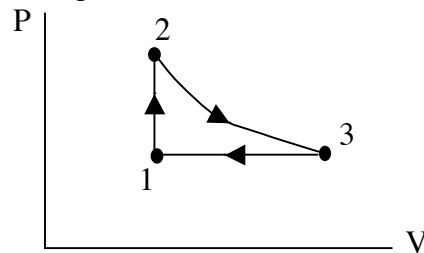
- Using this information only, calculate the force on one of the walls perpendicular to the x direction, in Newton. Note that the system is not in thermal equilibrium, so you cannot use e.g. the ideal gas law.

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(b) After some time, because of collisions between the atoms, the distribution of atomic speeds will become the Maxwell distribution, with the atoms moving now in all directions, not just the x direction. Assuming the total kinetic energy of the system did not change, find the temperature of the system, in K.

(c) Estimate by what factor will the force on the wall perpendicular to the x direction calculated in (a) have dropped when the system has reached thermal equilibrium. Justify your answer.

Problem 3 (10 pts + 3 pts extra credit)



5 mol of a monoatomic ideal gas are initially at point 1, then evolve quasistatically to 2, then to 3, then back to 1, as shown in the graph above. The process 2 to 3 is isothermic, 1 to 2 is constant volume, 3 to 1 is constant pressure.

$V_1=6\text{m}^3$, $T_1=300\text{K}$, $P_2=2P_1$. $R=8.314\text{J/mol K}$.

- Give T_2 in K and V_3 in m^3 .
- Give the heat absorbed or released by the gas in the process 1- \rightarrow 2, in J.
- Give the heat absorbed or released by the gas in the process 2- \rightarrow 3, in J.
- Give the heat absorbed or released by the gas in the process 3- \rightarrow 1, in J.
- Give the net heat absorbed or released over the entire cycle, in J, and the net work done by the system over the entire cycle, in J. Independent of your answers, state whether they should be the same or different, and why.

Hint: find the numerical value of nRT_1 ($n=5$) and express answers in terms of nRT_1 before computing their numerical values, to reduce use of the calculator.