Name:_____

SID: _____

Physics 7B Midterm 1 – Fall 2020
Professor A. Lanzara

TOTAL POINTS: 100

Show all work, and take particular care to explain what you are doing. Partial credit is given. Please use the symbols described in the problems, define any new symbol that you introduce and label any drawings that you make. All answers should be in terms of given variables or numbers. If you get stuck, skip to the next problem and return to the difficult section later in the exam period.

Problem 1 (20 pts.)

An ice cube of mass m_i and temperature T_i is floating in a glass filled with water.

2/3 of the ice cube volume is covered by the water while the remaining 1/3 is above the water line. The glass is filled to the brim and contains a mass m_w of water, at temperature T_w.

The walls of the container are adiabatic.

a) For which values of the mass m_i the ice will completely melt.

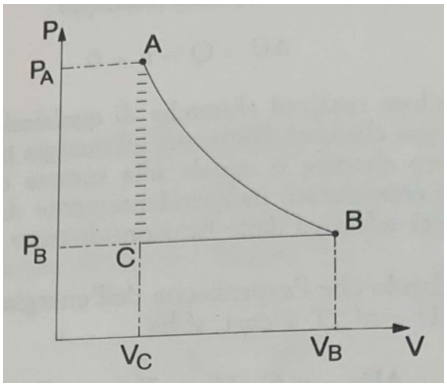
b) What happens after the ice has melted. Will the water spill out of the glass? Explain and demonstrate your answer in detail.

c) Find the equilibrium temperature of the system if the mass of the ice cube is $m_i=m_w/2$. Assume that all of the ice melts.

Take the specific heat of ice as c_i, the specific heat of water as c_w, and the latent heat of fusion for water as L_f. The density of water and ice are ρ_w and ρ_i, respectively.

Problem 2 (20 pts.)

One mole of an ideal monoatomic gas undergoes the cycle shown in the figure below. AB is a reversable isotherm at temperature T_A. BC is a reversable isobar at pressure P_B. CA is an irreversible isovolumetric process that brings the system back to the temperature T_A through an exchange of heat. If $V_B = 2V_C$ and $P_A = 2P_B$ find the work done by the gas during the cycle and the amount that it exchanges with the environment during the three transformations.



Problem 3 (15 pts.)

Consider a balloon of diameter D = 30.0 cm.

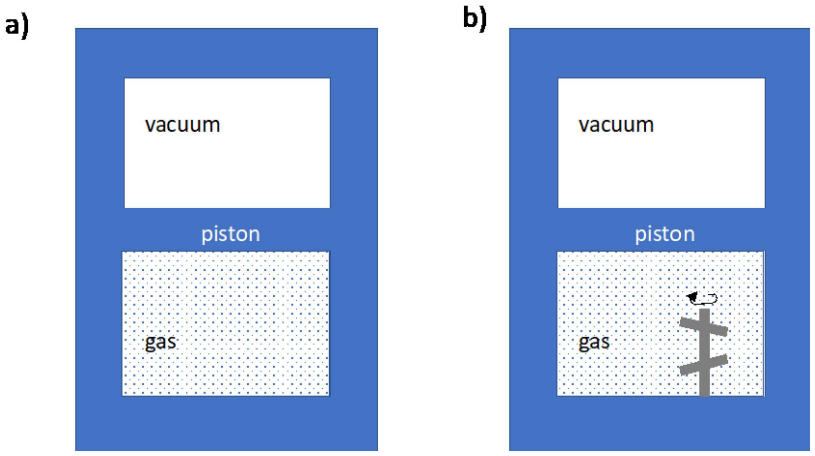
a) How many helium atoms can fit in the balloon at a temperature 20.0 ºC and pressure P=1 atm?
b) Find the average kinetic energy per helium atom.
c) Find the root mean square velocity.

Problem 4 (20 pts.)

An isolated container is divided into two parts by a piston of mass M and area A. The container is oriented vertically on the surface of the Earth. On one side of the container there is a diatomic gas, on the other side vacuum. The two are in thermal equilibrium. The volume occupied by the gas is V_1 and its temperature T_1.

a) The gas absorbs an amount of heat Q_1 and will reach a new equilibrium state with $V_2 > V_1$. Neglect the specific heat of the container and the piston. Find Q_1.

b) In addition to providing heat, we now submerge a paddlewheel of negligible specific heat in the gas. The paddle wheel will start to rotate and do work W. What is the total heat Q_2 absorbed by the system? Assume the final volume is once again V_2.



Problem 5 (25 pts.)

An ideal refrigerator works between an ideal reservoir at temperature T_2 and water of mass M at atmospheric pressure and at temperature T_1. The refrigerator works till half of the water is converted into ice. If the latent heat of solidification of water at 0^oC is L and assuming that the specific heat of water is constant C, answer the following:

a) What is the heat exchanged by the water?
b) What is the variation of entropy of the water?
c) Does your answer to part (b) make sense given the Second Law of Thermodynamics? Explain.
d) What is the work absorbed by the refrigerator?