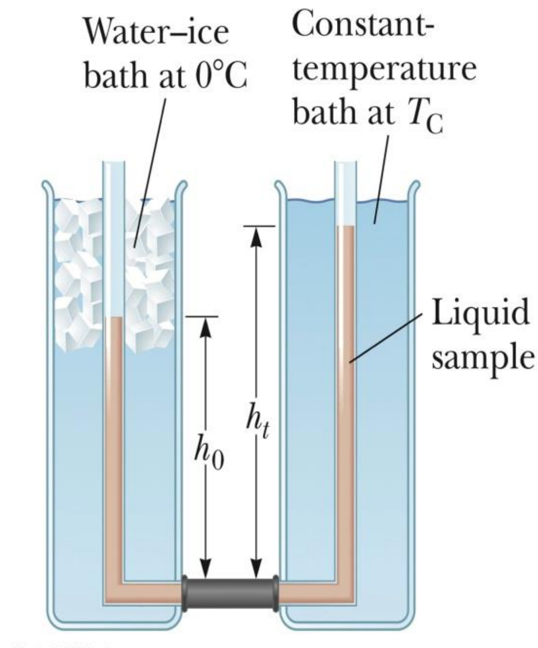
Assignment #2 – Due June 5th

Due: *Wednesday, June 5th, not later than 8:30 a.m. in class.*

Alternately, you may drop off this assignment June 5th not later than 8:15 a.m. in Professor Houtman's PHY1122 drop box on the 3rd Floor of the STEM building, just down the hall from Room 372.



Q1. The measurement of β, the coefficient of volumetric expansion, is complicated by the fact that the container in which the fluid sits may also expand, raising or lowering the apparent volume of the fluid depending on its own $\beta_{container}$. The apparatus shown at right compensates for this fact by reducing the calculation of β to just the ratio of the height of the two columns of the fluid, one at temperature T_o and the other at temperature T. The horizontal tube connecting the two branches, shown in black at the bottom of the U-tube, is assumed to be thermally insulated and has no effect of the experiment, regardless of its length or diameter. (a) Assume the fluid in the left side of the U-tube has density ρ_o at temperature T_0, while the fluid in the right side of the tube has density ρ_T at temperature T. Using the calculation for $V(T)$, (i.e. volumetric expansion with temperature) how does the density of a fluid vary as $\rho(T)$? (b) The pressure at the bottom of the U-tube must be the same (via Pascal's Law). Use this fact to calculate β as a function of T_0 and h_T/h_0. (Notice that by reducing the dependent variables from volume to pressure, we remove any dependence of the answer on $\beta_{container}$.)

Q2. In the previous question, we assumed that each side of the U-tube is enclosed in a large reservoir, so that the temperature remained constant despite the fact that heat flows between the two sides. In this question we change that assumption. First, assume the black connecting tube at the bottom of the apparatus (assumed to be perfectly insulating) has a cross-sectional area of 0.25 cm^2 and a length of 2.00 cm. Assuming the thermal conductivity, k, of the fluid in the U-tube is $20.0\ W/m°C$,

(a) how much power in W (i.e. J/s) is transferred through the horizontal tube, assuming the temperature of the left and right reservoirs is 0.0 ℃ and 25.0 ℃ respectively?

(b) Assume that the experimenter lets the apparatus sit overnight, but at midnight there is a power failure, so the temperatures of the cold and hot reservoir are no longer fixed at $T_0$and T, and they begin to warm-up or cool down as heat flows through the connecting tube. We'll make two assumption. First, that all the ice has melted in the left reservoir when the power failure happens, but the temperature of the water in the bath is initially still 0.0 ℃. Second, we'll assume constant power flow through the connecting tube, even though the temperatures in the reservoirs driving the heat flow actually change with time.

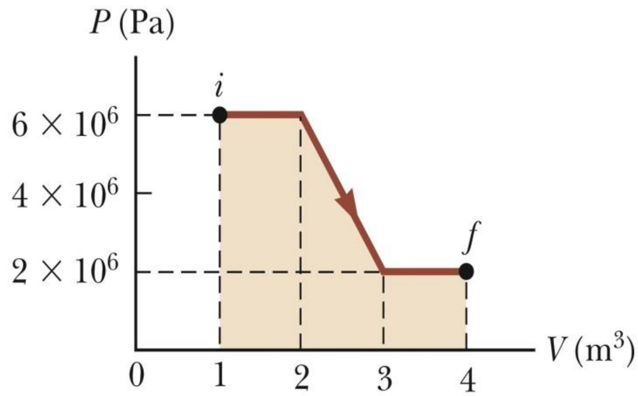
Assume both reservoirs are thermally isolated from the outside, and using the same power flow as you calculated in part (a), what will be the approximate temperature of the two reservoirs at 8:00 a.m., when the researcher returns? Assume that only the conducting fluid inside the U-tube plays any role in the transfer of heat between the two reservoirs, which are assumed to be filled with an equal mass of water.

(c) In part (b) we assumed that the heat flow was constant, based on the value obtained in part (a) Would you expect the actual temperature of the hot reservoir to be higher or lower than the value obtained in part (b)? Give reasons for your answer based on the law of heat conduction.

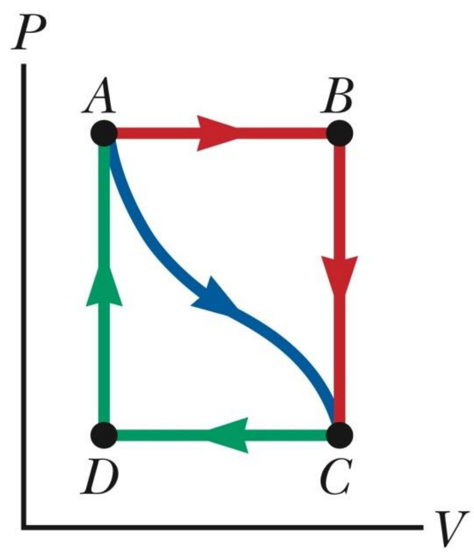
Q3. A 1.00-kg block of brass at 20.0 ^{o}C is dropped into liquid nitrogen at 77.3 K. How many kilograms of nitrogen boil away to cool the brass down 77.3 K? (The specific heat of brass is 385 J/kg ^{o}C and the latent heat of vaporization of nitrogen is 199000 J/kg)

Q4. A 50.0-g copper vessel contains 0.250 kg of water at 20.0 ℃. How much steam at $100℃$ must be condensed into the water if the final temperature of the system is to reach 50.0 ℃?

Q5.(a) Determine the work done on a gas that expands from i to f, as indicated in the figure at right. (b) How much work is done on the gas if it is compressed from f to i along the same path?



Q6. In the figure at right, the change in the internal energy ΔU of a gas that is taken from A to C along the blue path is +800 J. The work done on the gas along the red path ABC is -500J.



(a) How much energy must be added to the system by heat as it goes from A through B to C?

(b) If the pressure at point A is five times that of point C, what is the work done on the system in going from C to D?

(c) What is the energy exchanged with the surroundings by heat as the gas goes from C toA along the green path?

(d) If the change in internal energy in going from point D to point A is +500 J, how much energy must be added to the system by heat as it goes from point C to point D?