# Statistical Mechanics

September 27, 2006

Work 2 of the 3 problems. Please put each problem solution on a separate sheet of paper and put your name on each sheet.

## Problem 1

(A) The equation of state of a new type of matter has been found to be:

$$P = \frac{AT^x}{V}$$

where $P$, $V$ and $T$ are pressure, volume, and absolute temperature, respectively, and $A$ is a constant, while the exponent $x = 3$. The internal energy $U$ of this new type of matter is found to be:

$$U = BT^m \ln(V/V_0) + f(T)$$

where $B$, $m$ and $V_0$ are constants and $f(T)$ is a function which only depends on $T$.

Find $B$ and $m$.

[HINT: Use a thermodynamic function that involves the quantities you know and then exploit the fact that it is a function of state, namely that its differential is a true differential.]

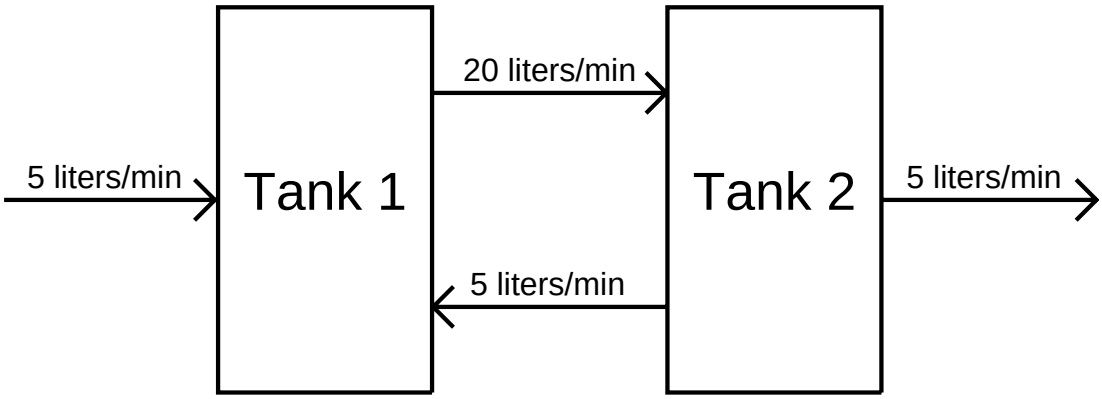
(B) When $x = 1$ and $A = nR$ ($n$ is the number of moles and $R$ is the gas constant), the above equation of state simplifies to the ideal gas law:

$$P = \frac{nRT}{V}$$

Using what you learned from above, what is the internal energy $U$ of an ideal gas?

# Problem 2

Two tanks large enough to hold any amount of liquid which may appear in this problem are shown in the figure. The arrows indicate flows into the tanks and out of the tanks. Initially, at $t = 0$, Tank 1 contains 100 liters of fresh water, whereas Tank 2 contains 100 liters of brine (a water/salt combination found in the sea) which contains $20\,g$ of dissolved salt. Find the amounts of salt $x(t)$ and $y(t)$ in Tanks 1 and 2, respectively, as a function of time between $t = 0$ and $t = 10$ min, assuming instantaneous stirring (Hint: The solution will lead to a simple linear system of differential equations).



# Problem 3

A classical monatomic ideal gas at constant temperature $T$ has a density of $n_0$ particles per unit volume. Find the number of collisions between one particle and the rest per unit time, assuming that the particles are rigid spheres of radius $r_0$ and mass $m$.