

# Physics 31A Final (250 pts MAX)

## MW 4:25-5:45pm, Fall 2003

- (a) Suppose that an ideal gas undergoes an infinitesimal isothermal expansion; show that the change in its entropy is proportional to the fractional change in its volume. Discuss how this relates to the gas's increased disorder.

(b) A 500-g piece of copper melts at  $1083^{\circ}\text{C}$ . Determine its change in entropy in the process.
- (a) Use the calculus to prove that the work done by an ideal gas in an adiabatic process is given by  $w = \frac{1}{1-\gamma}(P_f V_f - P_i V_i)$

(b) A heat engine is being designed to operate between  $200^{\circ}\text{C}$  and  $20.0^{\circ}\text{C}$ . At best, we should be prepared to supply an amount of heat  $Q$  to it in order to get out 1000 J of work. What is the value of  $Q$ ?
- A roast turkey (at time  $t=0$  and temperature  $T=T_0$ ) is taken out of the oven to cool and placed on a table near an open window. Write an expression for its temperature as a function of time.
- How much heat must be added to a 1.0-kg mass of water ice at  $-10^{\circ}\text{C}$  and atmospheric pressure, in order to transform it into superheated steam at  $110^{\circ}\text{C}$ ?
- The density of water in  $\text{g/cm}^3$  is roughly approximated by the expression  $\rho = \rho_0 [1 + (5.3 \times 10^{-5})T - (6.5 \times 10^{-6})T^2 + (1.4 \times 10^{-8})T^3]$  wherein  $\rho_0$  is the density at  $T=0^{\circ}\text{C}$ . Determine the value of  $T$  corresponding to the maximum density of water.
- A 10-kg lead bullet at  $23.0^{\circ}\text{C}$  slams into a stone wall and, squashing, comes to rest. Assuming no loss of energy to the environment, how fast must the bullet be traveling if it is to totally melt?
- Typically in dry air, the temperature of the atmosphere decreases by about  $1^{\circ}\text{C}$  for every rise of 150 m. Moreover,  $v(T)=331 \text{ m/s} + 0.60T \text{ m/s}$ , where  $T$  is the Celsius temperature. Thus, if a sound wave were traveling straight down through the atmosphere from a few thousand meters (neglecting density variations), determine its acceleration as a function of speed,  $a(v)$ .
- The human thigh bone, the femur, at its narrowest point resembles a hollow cylinder with an outer radius of roughly 1.1 cm and an inner radius of just about half of that. Taking the compressive strength of the bone to be 170 MPa, how much force will be required to rupture it?
- A long thin rod lying along the x-axis with its leftmost end at the origin is inhomogeneous. Its mass is given by the function  $m(x)=C\sqrt{x}$ , out to  $x=2.00\text{m}$ , wherein  $C$  is a constant equal to  $1.00 \text{ kg/m}^{1/2}$ . Find the mass-per-unit-length( $\lambda$ ) at  $x=1.00 \text{ m}$ .