

Physics 31A Final (300 pts MAX.)

Fall 2004

Show your works with diagrams, explanations and clear writings, no credit will be given for answers without diagrams, explanations, and clear writings.

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

(b) An ideal gas expands isothermally from V_i to V_f . Prove the associated entropy change is given by $\Delta S = nR \ln \frac{V_f}{V_i}$
- (a) A Carnot engine operates at an efficiency of 42.2% with a high-temperature reservoir at 473 K. If the efficiency is to be raised to 50% using a high-temperature reservoir, what will its temperature have to be?

(b) Determine the amount of work needed to compress 4.0g of oxygen at STP down to one-third its original volume, keeping the temperature constant. Assume it behaves as an ideal gas.
- (a) 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

(b) A 10.0 -g 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?
- How much heat must be added to a 1.0-kg mass of water ice at -10°C and atmospheric pressure, in order to transform it into superheated steam at 110°C ? Compare the energy associated with each stage of the process and confirm.
- (a) An automobile tire is pumped up to an absolute pressure of 33 lb/in^2 , with air at a temperature of 40.0°F . After driving for several hours, the temperature in the tire reaches 120°F . Find the pressure in the tire at that point in SI units.

(b) A container of gas is kept at a constant pressure (which is close to atmospheric) by supporting a glob of mercury as in Fig. If its volume is initially $500 \times 10^{-6} \text{ m}^3$ at a temperature of 273 K, what will it be at 300K?
- (a) The density of water in g/cm^3 is roughly approximated by the expression.

$$P = P_0 [1 + (5.3 \times 10^{-5}) T - (6.5 \times 10^{-6}) T^2 + (1.4 \times 10^{-8}) T^3]$$

- (b) Two thermometers, one marked in Fahrenheit and the other in Celsius, are placed in a bath. At what temperature will both thermometers read the same?
7. (a) A man running toward the stage in a theater hears an A_4 note from a stationary tuning fork to have a frequency of 441 Hz instead of its more normal 440 Hz. About how fast is he going?
- (b) Typically in dry air, the temperature of the atmosphere decreases by about 1°C for every rise of 150 m. Moreover, $v_T = 331\text{m/s} + 0.60 T \text{ m/s}$, 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, $a(v)$.
8. (a) What is the speed of sound at room temperature (20°C) and normal atmospheric pressure?
- (b) Someone turns on a radio at 65.0 dB while vacuuming the floor at 80.0dB. What will be the total sound-level in the room?
9. (a) A uniform solid ball of radius R and mass m is at rest at a height h atop an inclined plane making an angle θ , write an expression for the linear speed of the sphere at the bottom of the incline assuming it rolls without slipping. Compare that to the speed a hollow sphere of the same mass and size would attain.
- (b) A rocket engine testing a low-power fuel expels 5.0 kg of exhaust gas per second. If these molecules are ejected at an average speed of 1.2 km/s, what is the thrust of the engine?