

# Physics 31A Final (300 pts MAX.)

## Winter 2005

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

- (a) The density of water in  $\text{g/cm}^3$  is roughly approximated by the expression.  
$$P = P_o [1 + (5.3 \times 10^{-5}) T - (6.5 \times 10^{-6}) T^2 + (1.4 \times 10^{-8}) T^3]$$
Wherein  $P_o$  is the density at  $T = 0^\circ\text{C}$ , calculate the density at  $T = 10^\circ\text{C}$ . Determine the value of  $T$  corresponding to the max density of water.

(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?
- (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  $1^\circ\text{C}$  for every rise of 150 m. Moreover,  $vT = 331\text{m/s} + 0.60 T \text{ m/s}$ , 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,  $a(v)$ .
- (a) What is the speed of sound at room temperature ( $20^\circ\text{C}$ ) 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?
- (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  $\theta$ , 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?
- (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  $\Delta S = nR \ln \frac{V_f}{V_i}$

6. (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.
7. (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?
8. 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  $110^\circ\text{C}$ ? Compare the energy associated with each stage of the process and confirm.
9. (a) An automobile tire is pumped up to an absolute pressure of  $33 \text{ lb/in}^2$ , with air at a temperature of  $40.0^\circ\text{F}$ . After driving for several hours, the temperature in the tire reaches  $120^\circ\text{F}$ . 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?