Physics 10154 - Exam #5C

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work (or if some parts are incorrect) even if you get the right answer. Clearly indicate your answer with a circle or box and remember to include correct units and significant figures.

1. (25 pts) An ideal gas is in a sealed chamber so that the number of particles cannot change. The measured density of the gas is 0.255 kg/m³. The initial temperature of the gas is 85.0 °C. The pressure of the gas increases by a factor of 4.50, and the temperature increases to 215 °C. What is the new density of the gas?

$$\frac{V_2}{V_1} = \frac{\left(\frac{n_2}{n_1}\right)\left(\frac{R}{R}\right)\left(\frac{T_2}{T_1}\right)}{\left(P_2/P_1\right)} = \frac{(1)(1)\left(\frac{488}{358}\right)}{4.50}$$

$$= 0.303$$

$$\frac{\rho_2}{\rho_1} = \frac{\left(M_2/M_1\right)}{\left(V_2/V_1\right)} = \frac{1}{0.303}$$

$$\rho_2 = \frac{\rho_1}{.303} = \boxed{0.842 \text{ kg/m}^3}$$

2. (25 pts) For a monatomic ideal gas, the internal energy, U, can be given by 3/2 PV or 3/2 nRT. 2.2 moles of an ideal monatomic gas are at a temperature of 255 K. The temperature of the gas is then increased to 342 K while the gas does 588 Joules of work. How much heat has been added to the gas in order to accomplish this task?

$$\Delta U = \frac{3}{2} nR\Delta T = \frac{3}{2}(2.2)(8.31)(87)$$

$$= 2386\,J$$

$$2386 = Q - W_{by\ gas}$$

$$2386 = Q - 588$$

$$\boxed{Q = 2970\ J}$$

3. (25 pts) A car is driving along the highway with a speed of 28 m/s, and it strays on to the shoulder. Evenly spaced parallel grooves called "rumble strips" are caved into the pavement of the shoulder. Rolling over the rumble strips causes the car's wheels to oscillate up and down at a frequency of 94 Hz with an amplitude of 2.4 cm. Assuming the car's speed is the speed of the wave…

a) How far apart are the centers of adjacent rumble-strip grooves?
b) What is the maximum velocity of the wheel perpendicular to the direction of the car's travel?

a) $\lambda = \frac{V}{f} = \frac{28}{94} = \boxed{0.30\ m}$

b) $\omega = 2\pi f = 590.6$

$$V_{max} = A\omega = (.024)(590.6)$$

$$= \boxed{14\ m/s}$$

4. (25 pts) A speaker emits sound uniformly in all directions with no reflections. The intensity of the sound at a location 22 meters away from the source is 76 dB. What is the intensity at a location 75 meters away, in dB?

$$76 = 10 \log\left(\frac{I}{10^{-12}}\right)$$

$$10^{7.6} = \frac{I}{10^{-12}} \Rightarrow I = 10^{-4.4}$$

$$= 3.98 \times 10^{-5} \frac{W}{m^2}$$

$$P_s = I(4\pi r^2) = 0.242\ W$$

$$I_{new} = \frac{P_s}{4\pi r_{new}^2} = \frac{0.242}{4\pi(75)^2} = 3.43 \times 10^{-6} \frac{W}{m^2}$$

$$I(dB) = 10 \log\left(\frac{3.43 \times 10^{-6}}{10^{-12}}\right) = \boxed{65\ dB}$$

Shorter: $\Delta I = 10 \log\left(\frac{I_{old}}{I_{new}}\right) = 10 \log\left(\frac{1/22^2}{1/75^2}\right)$

$$= 10 \log(11.6)$$

$$= 10.7\ dB$$

So I_{new} is 11 dB less than I_{old}.