Physics 10154 - Exam #5B

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) A person with a body temperature of 98.6°F stands in a room with a temperature of 72.0°F with 1.20 square meters of skin exposed. The emissivity of the person's skin is 0.750. Assuming a food calorie is equal to 4186 Joules, how many food calories are consumed via radiation for this person in one hour?

$T = 98.6°F = 37°C = 310K$

$T_{env} = 72.0°F = 22.2°C = 295.2K$

$P = \sigma e (T^4 - T_{env}^4)(Area)$

$= (5.67 \times 10^{-8})(.750)(310^4 - 295.2^4)(1.2)$

$= (5.67 \times 10^{-8})(.750)(1.64 \times 10^{12})(1.2)$

$= 83.8\ W$

$E = P \Delta t = (83.8\ \frac{J}{s})(3600\ s) = 301,700\ J$

$301700J \cdot \frac{1\ Cal}{4186\ J} = \boxed{72\ Cal}$

2. (25 pts) An monatomic ideal gas occupies a volume of 12.5 cm^3 at a temperature of 74.0 °C and a pressure of 2.2 atm.

a) Determine the number of atoms of gas present.
b) If the gas is Neon (atomic mass = 20.2 u), determine the total mass of the gas sample (in kg).
c) If the pressure is increased to 3.2 atm while the temperature is decreased to 22.0 °C with the number of molecules kept constant, what is the new volume of the gas, in Liters?

a) $N = \frac{PV}{k_B T} =$ $P = 2.2\,atm = 222{,}860\,Pa$

$V = 12.5\,cm^3 = 12.5 \times 10^{-6}\,m^3$

$T = 74.0^\circ C = 347\,K$

$= \frac{(222{,}860)(12.5 \times 10^{-6})}{(1.38 \times 10^{-23})(347)} = \boxed{5.8 \times 10^{20}\ atoms}$

b) $m_{TOT} = N m_{atom} = (5.8 \times 10^{20})(20.2\,u)\left(\frac{1.66 \times 10^{-27}\,kg}{u}\right)$

$= \boxed{1.95 \times 10^{-5}\,kg}$

c) $\frac{V_2}{V_1} = \frac{\left(\frac{N_2}{N_1}\right)\left(\frac{k}{k}\right)\left(\frac{T_2}{T_1}\right)}{\left(P_2/P_1\right)} = \frac{(1)(1)\left(\frac{295}{347}\right)}{\left(3.2/2.2\right)} = 0.584$

$V_2 = 0.584\,V_1 = 7.3\,cm^3$

or $\boxed{.0073\,L}$ $7.3\,mL$

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) At a racetrack pit area, protective earplugs reduce the sound intensity by a factor of 440. When a car is revving its engine, the sound intensity experience by a pit crew member is 86 dB.

a) What sound intensity level (in dB) would the crew member experience if the earplugs were removed?
b) How many Joules of energy would enter the ear in an hour if the cross-sectional area of the ear opening is 1.1 cm^2 and no earplugs were in?

a) $\Delta I(dB) = 10 \log(440) = 26\ dB$

$$I_{new} = 86 + 26 = \boxed{112\ dB}$$

b) $$112 = 10 \log\left(\frac{I(W/m^2)}{10^{-12}}\right)$$

$$10^{11.2} = \frac{I}{10^{-12}} \Rightarrow I = 10^{-0.8} = 0.158\ \frac{W}{m^2}$$

$$P = IA = (0.158)(1.1 \times 10^{-4}\ m^2) =$$

$$= 1.74 \times 10^{-5}\ W$$

$$E = P\Delta t = (1.74 \times 10^{-5})(3600) = \boxed{.063\ J}$$