Recitation 5

•9 An automobile tire has a volume of 1.64×10^{-2} m^3 and contains air at a gauge pressure (pressure above atmospheric pressure) of 165 kPa when the temperature is 0.00°C. What is the gauge pressure of the air in the tires when its temperature rises to 27.0°C and its volume increases to 1.67×10^{-2} m^3? Assume atmospheric pressure is 1.01×10^5 Pa.

Remember!

$$p_g = p - p_0$$

$$p_1V_1 = nRT_1 \Rightarrow n = \frac{p_1V_1}{RT_1}$$

$$p_2 = \frac{nRT_2}{V_2} = \frac{p_1V_1}{RT_1}\frac{RT_2}{V_2} = p_1\frac{V_1T_2}{V_2T_1}$$

$$= (2.66 \times 10^5\ \mathrm{Pa})\frac{(1.64 \times 10^{-2}\ \mathrm{m}^3)(300\ \mathrm{K})}{(1.67 \times 10^{-2}\ \mathrm{m}^3)(273\ \mathrm{K})}$$

$$= 2.87 \times 10^5\ \mathrm{Pa}.$$

$$p_{g2} = p_2 - p_0 = 1.86 \times 10^5\ \mathrm{Pa}.$$

•**18** The temperature and pressure in the Sun's atmosphere are 2.00×10^6 K and 0.0300 Pa. Calculate the rms speed of free electrons (mass 9.11×10^{-31} kg) there, assuming they are an ideal gas.

$$v_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3RT}{m_e N_A}} = \sqrt{\frac{3\left(8.31 \frac{\text{J}}{\text{mol} \cdot \text{K}}\right)(2.00 \times 10^6\ \text{K})}{(9.11 \times 10^{-31}\ \text{kg})(6.02 \times 10^{23}\ \text{mol}^{-1})}}$$

$$= 9.53 \times 10^6\ \frac{\text{m}}{\text{s}}.$$

••48 When 20.9 J was added as heat to a particular ideal gas, the volume of the gas changed from 50.0 cm^3 to 100 cm^3 while the pressure remained at 1.00 atm. (a) By how much did the internal energy of the gas change? If the quantity of gas present was 2.00×10^{-3} mol, find (b) C_p and (c) C_V.

a)

$$W = p\Delta V = (1.01 \times 10^5 \text{ Pa})(100 \times 10^{-6} \text{ m}^3 - 50.0 \times 10^{-6} \text{ m}^3) = 5.05 \text{ J}.$$

$$\Delta E_{\text{int}} = Q - W = 20.9 \text{ J} - 5.05 \text{ J} = 15.9 \text{ J}.$$

b)

$$C_p = \frac{Q}{n\Delta T} = \frac{QR}{nR\Delta T} = \frac{QR}{p\Delta V} = \frac{QR}{W} = \frac{20.9 \text{ J}}{5.05 \text{ J}} R = 4.13\, R.$$

c)

$$C_V = C_p - R = 3.13\, R.$$

••**52** Suppose 12.0 g of oxygen (O_2) gas is heated at constant atmospheric pressure from 25.0°C to 125°C. (a) How many moles of oxygen are present? (See Table 19-1 for the molar mass.) (b) How much energy is transferred to the oxygen as heat? (The molecules rotate but do not oscillate.) (c) What fraction of the heat is used to raise the internal energy of the oxygen?

a)

$$n = \frac{M_{\text{sam}}}{M} = \frac{12.0\ \text{g}}{32.0\ \text{g/mol}} = 0.375\ \text{mol}.$$

b)

$$Q = nC_p\Delta T = (0.375\ \text{mol})\left(\frac{7}{2}8.31\,\frac{\text{J}}{\text{mol}\cdot\text{K}}\right)(125°\text{C} - 25°\text{C}) = 1.09 \times 10^3\ \text{J}.$$

c)

$$\frac{E_{\text{int}}}{Q} = \frac{nC_V\Delta T}{nC_p\Delta T} = \frac{C_V}{C_p} = \frac{\frac{5}{2}R}{\frac{7}{2}R} = \frac{5}{7} = 0.714.$$

•55 A certain gas occupies a volume of 4.3 L at a pressure of 1.2 atm and a temperature of 310 K. It is compressed adiabatically to a volume of 0.76 L. Determine (a) the final pressure and (b) the final temperature, assuming the gas to be an ideal gas for which $\gamma = 1.40$.

a)

$$p_f V_f^{\gamma} = p_i V_i^{\gamma}$$

$$p_f = p_i \left(\frac{V_i}{V_f}\right)^{\gamma} = (1.2 \text{ atm}) \left(\frac{4.3 \text{ L}}{0.76 \text{ L}}\right)^{1.40} = 14 \text{ atm.}$$

b)

$$T_f V_f^{\gamma-1} = T_i V_i^{\gamma-1}$$

$$T_f = T_i \left(\frac{V_i}{V_f}\right)^{\gamma-1} = (310 \text{ K}) \left(\frac{4.3 \text{ L}}{0.76 \text{ L}}\right)^{0.40} = 620 \text{ K.}$$