Homework Assignment 3

Stephen R. Addison

February 26, 2001

HW14 According to quantum mechanics, the molecules of a diatomic gas have rotational energy levels

$$\epsilon_r = \frac{\hbar^2}{2I} r(r+1), \quad r = 0, 1, 2, \ldots$$

where I is a constant, the level ϵ_r is $(2r+1)$-fold degenerate. Write down an expression for the rotational motion partition function. Use it to find expressions for the molar rotational heat capacities at high and low temperature. For carbon monoxide, $I = 1.3 \times 10^{-39} g\ cm^2$. What is the molar rotational heat capacity if carbon monoxide at room temperature? (2 points)

HW15 To a good approximation, a diatomic molecule can be thought of as vibrating in one-dimensional simple harmonic motion with angular frequency ω. In quantum mechanics such systems possess an infinite set of non-degenerate energy levels with energy $\hbar\omega(r + \frac{1}{2},\ r = 0, 1, 2, \ldots, \infty$. Find expressions for the vibrational partition function and the vibrational heat capacity. What are the high and low temperature limits of this heat capacity. Find the molar vibrational heat capacity of N_2 at 1200 K given that $\hbar\omega = 0.3\ eV$. (3 points)

HW16 At its normal boiling point of 630 K, saturated mercury vapor is monatomic and follows the ideal gas laws. Calculate the entropy per mole of saturated mercury vapor at its norma l boiling point. (2 points)

HW17 A diatomic molecule consists of masses M_1 and M_2 with position coordinates $\vec{r}_1$ and $\vec{r}_2$. The atoms interact through an attractive potential $|\vec{r}_1 - \vec{r}_2|$. Show that the energy of the molecule decomposes into translational, rotational, and vibrational parts. (4 points - this problem requires you to use your knowledge of mechanics.)

HW18 Page 112, problem 1 (1 point)

HW19 Page 112, number 2 (3 points)

HW20 Page 113, number 5 (5 point)

HW21 Page 114, number 8 (3 points)