CHEM 3423 001 Spring 2026 **Name:**

ID: KEY

Worksheet # 3 (Total number of points you can get is 3 pts)

1. Hydrogen gas has a molecular collision diameter of 0.258 nm. Calculate the mean free path of hydrogen at 300 K and 200 kPa. ($k_B = R/L = 1.381 \times 10^{-23}$ J/K)

$$\lambda = \frac{V}{\sqrt{2}\,\pi d_A^2 N} \quad , \quad \frac{V}{N} = \frac{RT}{LP} \Rightarrow \lambda = \frac{RT}{\sqrt{2}\,\pi L P d_A^2}$$

$$\simeq 7.00 \cdot 10^{-8}\ m$$

2. Suppose we have a gas consisting of molecules A. The temperature is raised from T_1 to $T_2 = 2T_1$. What is the relationship between collision frequencies Z_A at T_1 and Z_A at T_2?

$$Z_A = \frac{\sqrt{2}\,\pi d_A^2 N_A}{V} \bar{u}_A \qquad \bar{u}_A = \sqrt{\frac{8 k_B T}{\pi m}} \Rightarrow u_A(T_2) = \sqrt{2}\, u_A(T_1)$$

Text

$$\Rightarrow Z_A(T_2) = \sqrt{2}\, Z_A(T_1)$$

3. For H_2 gas at 400 K, calculate the ratio of the fraction of molecules that have the speed $u_2 = 2u_1$ to the fraction that have speed u_1. Assume that $u_1 = \bar{u}$ (the average speed of molecules at this temperature).

$$\frac{N(u)}{N} = 4\pi \left(\frac{m}{2\pi k_B T}\right)^{3/2} e^{-mu^2/k_B T} \cdot u^2 du$$

$$\frac{N(u_2)}{N(u_1)} = \frac{u_2^2}{u_1^2} \exp\left(-\frac{m}{2k_B T}(u_2^2 - u_1^2)\right) = 4 \exp\left(-\frac{m}{2k_B T}(4-1)u_1^2\right)$$

$$= 4 \exp\left(-3\frac{m}{2k_B T} u_1^2\right) \qquad u_1 = \bar{u} = \sqrt{\frac{8 k_B T}{\pi m}}$$

$$= 4 \exp\left(-\frac{3m}{2k_B T} \cdot \frac{8 k_B T}{\pi m}\right) = 4 \exp\left(-\frac{12}{\pi}\right) = 0.088$$