\[ R = 8.3145 \text{ J/K mol} = 1.9872 \text{ cal/K mol} = 0.082058 \text{ L atm/K mol} \]

1.000 L atm = 101.3 J

\[ \mathcal{F} = 96,485 \text{ C/mol} \]

\[ (p + \frac{an^2}{\nu^2})(V - nb) = nRT \]

\[ \int_0^\infty x^n e^{-ax^2} \, dx = \frac{1}{2} \left( \frac{\pi}{a} \right)^{\frac{1}{2}} \text{ (for n=0)}, \quad \frac{1}{2a} \text{ (for n=1)}, \quad \frac{1}{4} \left( \frac{\pi}{a^3} \right)^{\frac{1}{2}} \text{ (for n=2)}, \quad \frac{1}{2a^2} \text{ (for n=3)}, \quad \frac{3}{8} \left( \frac{\pi}{a^5} \right)^{\frac{1}{2}} \text{ (for n=4)} \]

\[ \int_0^\infty x^{2n-1} e^{-ax^2} \, dx = \frac{1 \cdot 3 \cdot 5 \cdot (2n-1)}{2^{n-1} a^n} \left( \frac{\pi}{a} \right)^{\frac{1}{2}} ; \quad \int_0^\infty x^{2n+1} e^{-ax^2} \, dx = \frac{n!}{2a^{n+1}} \]

\[ \int_0^\infty x^n e^{-ax} \, dx = \frac{n!}{a^{n+1}} \]

\[ \sqrt{\frac{2kT}{m}} \quad \frac{8kT}{\pi m} \quad \frac{m}{2\pi kT} e^{-\frac{mv^2}{2kT}} \quad 4\pi \left( \frac{m}{2\pi kT} \right)^{\frac{3}{2}} v^2 e^{-\frac{mv^2}{2kT}} \]

\[ \sqrt{\frac{2}{\pi d^2}} \langle \nu \rangle \frac{N}{V} = \frac{1}{\sqrt{2\pi d^2}} \frac{N}{V} = \frac{1}{4} \langle \nu \rangle \frac{N}{V} \quad \frac{\pi d^2}{\sqrt{2}} \langle \nu \rangle \frac{N}{V} \quad \pi d^2 \langle \nu \rangle \left( \frac{N_A}{V} \right) \left( \frac{N_B}{V} \right) \]

\[ \frac{\lambda}{3} \langle \nu \rangle = \frac{m}{3} \langle \nu \rangle \frac{N}{V} = \frac{\langle \nu \rangle}{3} \frac{C_V N}{N_A V} \]

\[ \text{Total} \]

Name

1. _______

2. _______

3. _______

4. _______

5. _______

6. _______

7. _______

8. _______
1. (20)
   a. Define Boltzmann's constant, \( k \).

   b. Define the rms average speed.

   c. Write the formula for the rms average speed of a molecule of mass, \( m \), at temperature, \( T \).

   d. Write an unambiguous expression for the reaction velocity for the reaction, \( 2A + 3B \rightarrow 4C + 5D \).

   e. Write a rate law which is first order in the reactant, \( A \), and first order in the reactant, \( B \).

   f. Write the reaction velocity, \( \frac{d[B]}{dt} \), implied by the elementary reaction step, \( \frac{k_f}{k_r} \).

   g. Describe the mean free path in words.

   h. What causes the pressure of a gas?

   i. Explain in words the meaning of \( f(v_x)dv_x \).

   j. Write the Michaelis-Menton mechanism for enzyme kinetics with enzyme, \( E \), and substrate, \( S \).

2. (10) The speed probability distribution function for molecules moving on a surface (two dimensions) is \( c v e^{-\frac{mv^2}{2kT}} \), where \( c \) is a constant. Find \( c \).
3. (10) Calculate \( \langle v^2 \rangle \) (the average of the square of the speed).

4. (15) \(^{14}\text{C}\) is a beta emitter and has a half-life of 5730 years. (1 year = 31,556,926 s.) Given a current sample of \(1.00 \times 10^{-6}\) g of \(^{14}\text{C}\) how many electrons would this sample emit per second after 10,000 years.
5. (10) The reaction, \(2 \text{A} + \text{B} \rightarrow \text{C} + \text{D}\), follows the rate law, \(\frac{d[B]}{dt} = -k[A][B]\). Find an expression for \([B]\) as a function of \(t\) under the condition that the reactants are initially present in their stoichiometric proportions.

6. (10) Consider the reaction, \(\text{A} \rightarrow \text{B} + \text{C}\). It is proposed that the mechanism for this reaction is:

\[
\begin{align*}
\text{A} + \text{A} & \xrightarrow{k_1} \text{A}^* + \text{A} \\
\text{A}^* + \text{A}^* & \xrightarrow{k_2} \text{B} + \text{C}
\end{align*}
\]

a. Define the rate as the rate of production of \(\text{B}\).

b. Use the steady state approximation to find the rate law implied by this mechanism.
7. (10) A certain second order reaction has a rate constant of 146 /M s at 25°C. What would be the rate at 50°C if the activation energy is 41.5 kJ?

8. (15) Find an expression for the relaxation time, \( \tau \), in terms of \( k_a \) and \( k_b \) and equilibrium concentrations, for the fast reaction, 

\[
\frac{k_a}{k_b} A + B \rightleftharpoons C + D
\]