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Chemistry: Estimation of Henry's Law Constant

Given Data and Introduction:

Mole fractions (x) and partial pressures (P) of methyl chloride at $298 \, \text{K}$ are given in the table below to estimate Henry's law constant:

- $x = 0.0005 \, \Rightarrow \, P = 0.27 \, \text{bar}$
- $x = 0.0009 \, \Rightarrow \, P = 0.48 \, \text{bar}$
- $x = 0.0019 \, \Rightarrow \, P = 0.99 \, \text{bar}$
- $x = 0.0024 \, \Rightarrow \, P = 1.24 \, \text{bar}$

Explanation:

The relationship between the partial pressure of a gas and its mole fraction in a solution is given by Henry's law:

Henry's law: $P = k_H \cdot x$

where:

- P = Partial pressure of the gas (in bar)
- k_H = Henry's law constant (in bar)
- x = Mole fraction of the gas

Step-by-Step Calculations:

Step 1: Compute Henry's Law Constant for each given pair:

- For $x = 0.0005$ and $P = 0.27 \, \text{bar}$:

  $$k_H = \frac{P}{x} = \frac{0.27}{0.0005} = 540 \, \text{bar}$$

  Explanation: Dividing the partial pressure by the mole fraction to find k_H.
- For $x = 0.0009$ and $P = 0.48 \, \text{bar}$:

  $$k_H = \frac{P}{x} = \frac{0.48}{0.0009} = 533.33 \, \text{bar}$$

  Explanation: Repeating the calculation to find k_H for the next data point.
- For $x = 0.0019$ and $P = 0.99 \, \text{bar}$:

  $$k_H = \frac{P}{x} = \frac{0.99}{0.0019} = 521.05 \, \text{bar}$$

  Explanation: Applying the same formula for the next pair.
- For $x = 0.0024$ and $P = 1.24 \, \text{bar}$:

  $$k_H = \frac{P}{x} = \frac{1.24}{0.0024} = 516.67 \, \text{bar}$$

  Explanation: Applying the same formula for the last pair.

Step 2: Calculate the average Henry's Law Constant:

- $$\text{Average } k_H = \frac{540 + 533.33 + 521.05 + 516.67}{4} = 527.76 \, \text{bar}$$ Explanation: Summing up all individual k_H values and dividing by 4 (number of data points).

Final Solution:

The estimated Henry's law constant of methyl chloride at $298 \, \text{K}$ is approximately $527.76 \, \text{bar}$.