Answer on Question #39948

Physics – Molecular Physics | Thermodynamics

Question:

Van der Waals equation for a real gas Discuss the origin of the constants a and b, and give their respective units.

Solution:

The van der Waals equation for one mole of real gas reads

$$RT = \left(p + \frac{a^2}{V_m^2} \right)(V_m - b),$$

where constants a and b are unique for the each gas. It appears if one takes into account attraction between molecules which results in the constant a:

$$[a] = \frac{Pa \cdot m^6}{mol^2},$$

and own volume of molecules which results in the constant b:

$$[b] = \frac{m^3}{mol}.$$

Van der Waals equation can be obtained in approach where molecules are described as rigid balls with conditions

$$P \gg \frac{a}{V_m^2} \text{ and } V_m \gg b.$$

These constants can be obtained as following:

$$a = -2\pi N_A^2 \int\limits_{d}^{\infty} U(r) r^2 dr, \qquad b = \frac{2}{3} N_A \pi d^3,$$

where N_A is the Avogadro constant and d is the diameter of molecule. Van der Waals equation describes real gases only approximately and usually is used as semi empirical. The corresponding constants are dependent on the temperature and often are measured in experiment for the further usage instead of analytical calculations.