Answer on Question #66746, Physics / Molecular Physics | Thermodynamics

Establish van der Waals' equation of state for a real gas. Plot van der Waals' equation of state on p-V diagram.

Solution:

The ideal gas law:

$$pV = nRT \text{ (1)},$$

where p is the pressure of the gas, V is the volume of the gas, n is the amount of substance of gas (in moles), R is the universal gas constant, T is the absolute temperature of the gas.

For n=1 mol:

$$pV = RT \text{ (2)}$$

The van der Waals equation of state for a real gas is based on plausible reasons that real gases do not follow the ideal gas law. The ideal gas law treats gas molecules as point particles that do not interact except in elastic collisions.

The van der Waals equation replaces V in the ideal gas law with (V-b), where b is the volume per mole that is occupied by the molecules:

$$p(V_m - b) = RT \text{ (3)},$$

where V_m is the molar volume, b is the van der Waals constant (correction for volume of molecules)

The van der Waals equation provided for intermolecular attraction by adding to the observed pressure P in the equation of state a term V_m^2. The van der Waals equation of state for a real gas is written as;

$$\left(p + \frac{a}{V_m^2}\right)(V_m - b) = RT \text{ (4)},$$

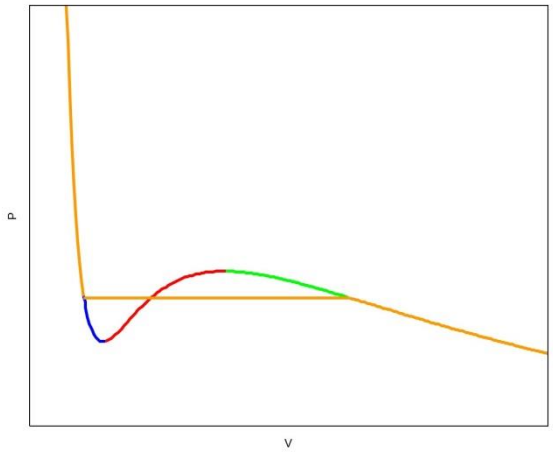
where a is the van der Waals constant (correction for molecular attraction), constants a and b have different values for each gas.

The van der Waals equation for n moles can also written as;

$$\left(p + \frac{an^2}{V^2}\right)(V - nb) = nRT \text{ (5)},$$

where V is volume of gas

Isotherm for van der Waals equation is shown in Figure.



pressure increases with decreasing of volume for large volumes (yellow curve);

pressure decreases with decreasing of volume (red curve);

real gas (the horizontal yellow line);

metastable states (blue and green curves)