Gaseous state

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By

Dr. Supriya kumari

J.L.N college,Dehri-on-Sone(Rohtas)

V.K.S.U,Ara

upriyachemu@gmail.com

Gaseous state

Contents:

- Vander Wall equation
- Various equations of state for real gases with special emphasis on Vander Wall equation of state
- Application
- Calculation of Boyle's temperature.

VAN DER WAALS EQUATION

VAN DER WAALS EQUATION :

- The deviations from ideal gas behaviour can be ascertained to the following faulty assumptions by kinetic theory of gases.
- Note: If the gases obey the kinetic theory of gases, then they cannot be compressed since the attractions between the gas molecules is negligible.

Significance of **van der Waals equation**

- It is a state equation for real gases that modifies the ideal gas equation (PV = nRT) in order to consider intermolecular interactions.
- These interactions result from molecules attracting each other when they are approaching, and repelling each other when they are colliding.

Van der Waals Equation

There are several ways to derive the Ideal Gas Law, but the simplest way is to use the three simple gas laws.

- AVOGADRO'S LAW states the volume of a gas is directly proportional to the number of moles.
- BOYLE'S LAW states that the volume of a gas is inversely proportional to its pressure.
- DERIVATION OF VANDER WAALS EQUATION.

For real gas, using Van der Waals equation,

the volume of a real gas is given as (Vm – b), where b is volume occupied by per mole.

Note :Van der Waals equation can be reduced to ideal gas law as $PV_m = RT$.

Van der Waals application

- Used for the correlation and the prediction of the lower critical solution behavior or mixtures including a solvent and a polymer.
- The equation of state parameters for the polymer are estimated from experimental volumetric data at low pressuers.
- Generalizes the ideal gas law which says that real gases do not act ideally.

Derivation of Van der Waals equation

For real gas **Van der Waals equation**

[P+V2n2a](V−nb)=nRT

the volume of a real gas is given as **(Vm – b)**

where b is volume occupied by per mole.

Thus, Van der Waals equation can be reduced to ideal gas law as $\mathbf{PV_m = RT}$

The **van der Waals equation** of state approaches the ideal gas law PV=nRT as the values of these constants approach zero.

The constant a provides a correction for the intermolecular forces.

Constant **b** is a correction for finite molecular size and its value is the volume of one mole of the atoms or molecules.

Calculation of Boyle's temperature

- Temperature at which real gas obeys the gas laws over a wide range of pressure is called Boyle's Temperature
- Ex: T_b of O_2 = 406 K Gases which are easily liquefied have a high Boyle's temperature
- T_b of He = 23 K gases which are difficult to liquefy have a low Boyle's temperature

- The temperature at which a real gas behaves like an ideal gas for wide range of low pressure values.
- At a particular temperature called Boyle temperature
- Value of compressibility factor Z tends to close to 1 or equal to 1 for varying pressures(particularly at low pressure range)

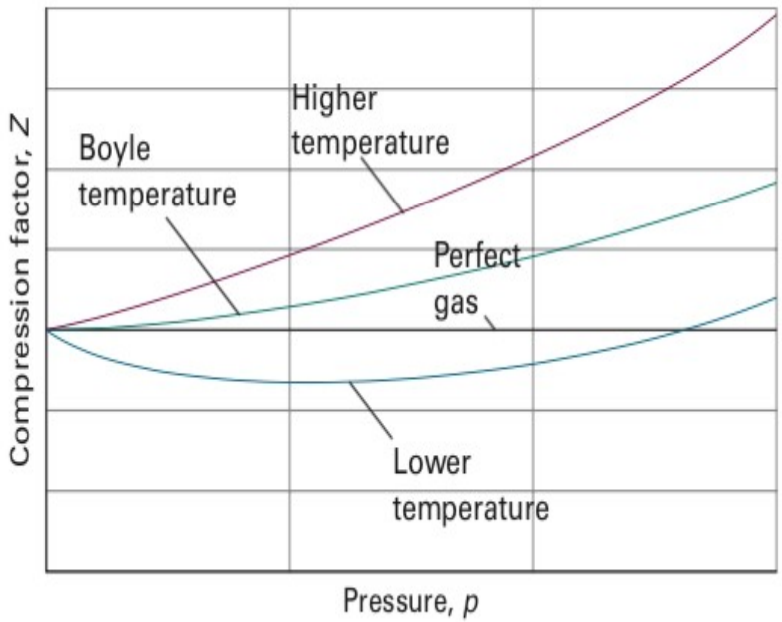
Boyle's Temperature

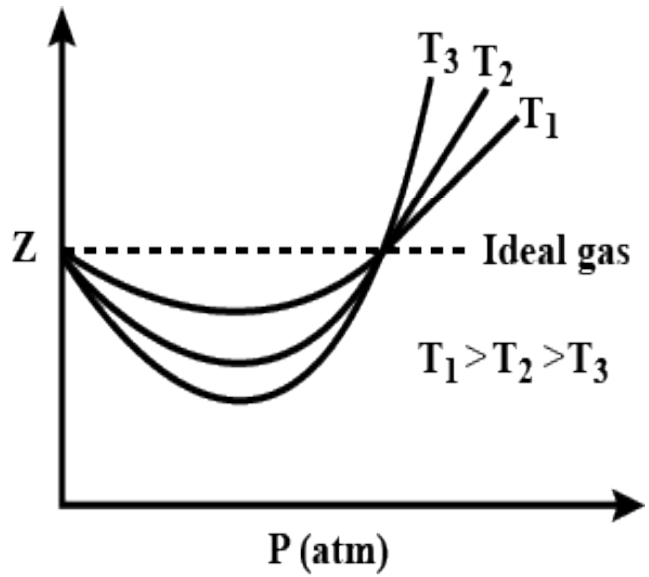
- The Boyle temperature is formally defined as the temperature for which the second virial coefficient, $B_2(T)$ becomes zero.
- It is at this temperature that the attractive forces and the repulsive forces acting on the gas particles equalize
- Virial equation of state which describes a real gas

$$P = RT\left[1/V_m + B_2T/V^2_m + \ldots\right]$$

Since higher order virial coefficients are usually much smaller than the second coefficient, the gas behave as an ideal gas over a wider range of pressures when the temperature reaches the Boyle temperature or when $C=1/V_m$ or p are minimized.

Boyle's Temperature





Plot at Boyle's temperature for the gas

Image taken from google

Question to be answered:

Q1. Why do we use vander Waals equation?

Q2.What are A and B in van der Waals equation?

Q3.What is the unit of A and B in van der Waals equation?

Q4. What happens at Boyle's temperature?

Q5. What is Boyle point or Boyle temperature?