Gaseous state

For

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Lecture-03

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Gaseous state

Contents:

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- Compressibility factor
- Derivation from ideality

Real gases

Ideal gas

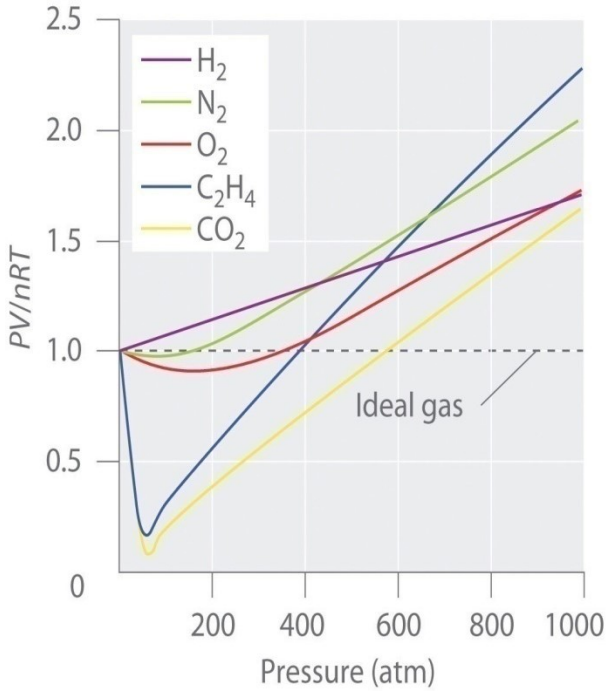
- An ideal gas is one that follows the gas laws at all conditions of temperature and pressure.
- An ideal gas follow the kinetic-molecular theory.

Real gas

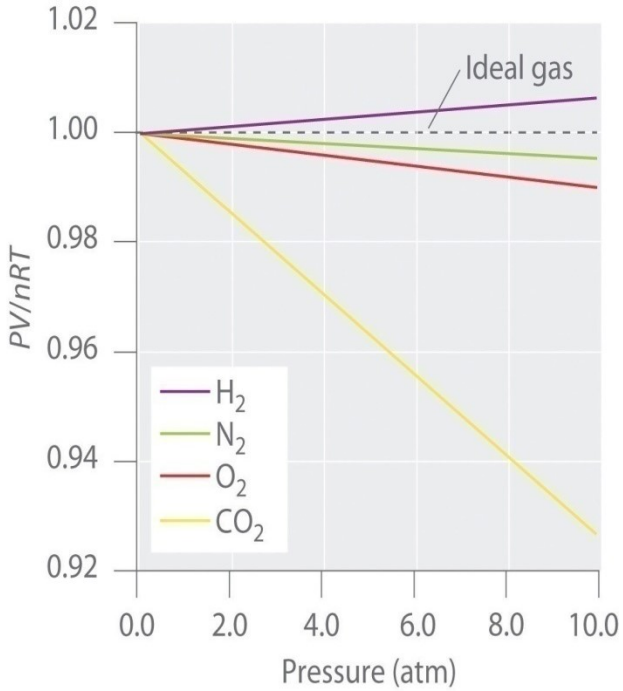
A real gas is a nonideal gas that does not behave according to the assumptions of the kinetic-molecular theory.

- Real gases are nonideal gases whose molecules occupy space
- Real gases have interactions
- Molecular dissociation and elementary reactions with variable composition must have to know to understand real gases.

Real gases



(a) *PV/nRT* at high pressures



(b) *PV/nRT* at low pressures

Real Gases

- Only real gasses exist in nature.
- No ideal gas exist in nature on normal conditions.
- All the gasses around us are real gasses because they do not obey gas laws but obey van der wall's equation

Condition for changing real to ideal:

A real gas change into ideal gas when

Temperature: high

Pressure: low

Because molecule occupy no volume relative to container

$$\frac{P\cancel{V}}{\cancel{V}} = \frac{nRT}{V}$$

Density

Compressibility factor

- The **compressibility factor** (Z), also known as the **compression factor** or **the gas deviation factor,** is a **correction factor** which describes the deviation of a real gas from ideal gas behaviour.

- It is a useful thermodynamic property for modifying the ideal gas law to account for behavior of real gases.
- It is a measure of how much the thermodynamic properties of a real gas deviate from those expected of an ideal gas.
- Compressibility represented as $Z = pV/RT$ is unity for an ideal gas.
- $v_{real} = Z\ v_{id}$ is used to calculate the actual volume, v_{real} as the product of the compressibility factor and the ideal gas volume, all at the same pressure and temperature.

Compressibility factor

- There are no attractive or repulsive forces between the molecules of an ideal gas, the actual volume will be the same as ideal volume.
- The compressibility factor is equal to 1.
- Compressibility factor will be greater than one at high temperatures.

Ideal gases will have a Z of 1 and real gases have a Z that is either greater or less than 1.

Compressibility factor

- The temperature does not have a large effect on the Z factor but high pressure will cause gases to have a high Z factor.
- Ideal gases Z = 1 and
- Real gases Z> 1 or Z<1.
- There is no large effect of temperature on the Z factor, but high pressure will cause gases to have a high Z factor.
- The ratio of the volume occupied by a real gas divided by the volume occupied by an ideal gas at the same temperature and pressure.

Where V_m is the molar volume of the gas

P is the value of Pideal

Derivation from ideal behaviour

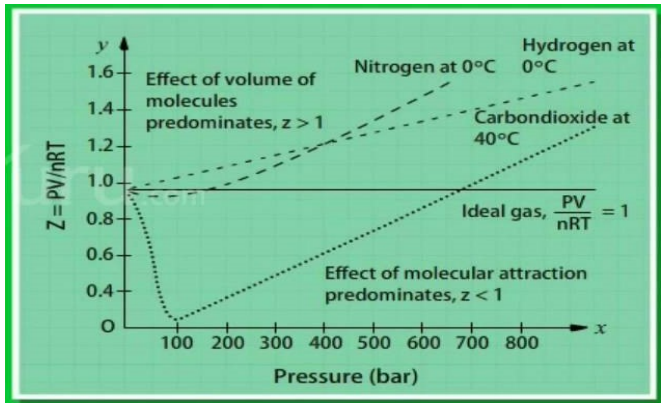
- Deviation of real gas from the the ideal behavior can be unnderstood by **compressibility factor** (Z)

$$Z = PV/nRT$$

Ideal gas $PV = nRT$ where $Z=1$

Real gas $PV \neq ZnRT$ where $Z \neq 1$ ($Z<1$ or $Z>1$)

Negative deviation(more Compressible than expected from ideal behaviour)



A plot of compressibility as a function of P for some gases.

Image taken from google

Derivation from ideal behaviour

Reason for deviation from ideal Behaviour:

- Real gases deviate significantly from ideal gas behavior at low temperatures or high pressures.
- Gas particles occupy a negligible fraction of the total volume of the gas as per the assumption of kinetic theory .
- It also assumes that the force of attraction between gas molecules is zero or negligible..

Question to be answered:

Q1. What are real gases and ideal gases? Give an example:

Q2. Do real gases exist?

Q3. What are the causes of deviation of real gas from ideal behaviour?

Q4. Why do hydrogen and helium always show positive deviation from ideality?

Q5. What is compressibility factor for ideal gas? Write the unit of compressibility?

Q6. What is critical compressibility factor?