جامـــــعـة المـــســتـقـبـل
AL MUSTAQBAL UNIVERSITY

كلية العلـــــوم
قــســـــــــم الادلة الجنائية

Lecture (4)

Equation of state and Ideal Gas

Second stage

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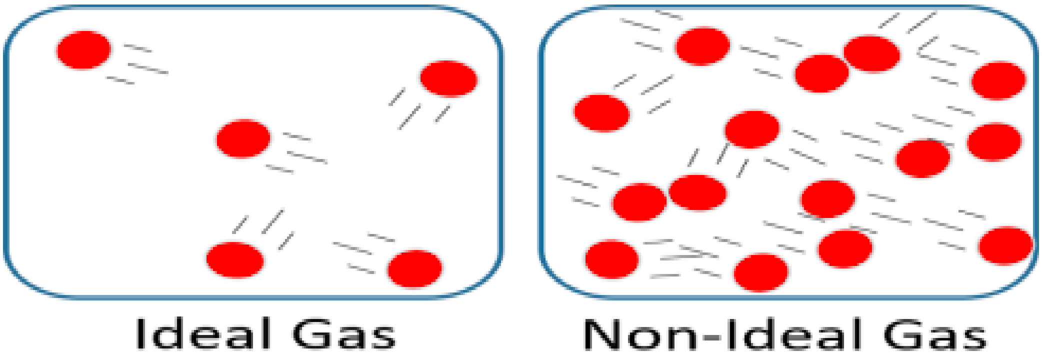
A real gas is defined as a gas that does not obey gas laws at all standard pressure and temperature conditions. When the gas becomes massive and voluminous it deviates from its ideal behavior. Real gases have velocity, volume and mass. When they are cooled to their boiling point, they liquefy. Oxygen, hydrogen, carbon dioxide, helium, and other gases are examples of real gas. Real gases exhibit modest attraction and repulsive forces between particles, but ideal gases do not. Real gas particles have a volume. An ideal gas is a physical thermodynamic model of the behavior of matter in the gaseous state. The model assumes that there is no interaction between gas molecules and that gas molecules are point-like. Therefore, it is suitable for describing gases with low density. It also applies to inert gases such as helium, neon, and argon, which are not molecules and their atoms are single. This gas meets the following conditions:

1- The volume of gas molecules is neglected relative to the volume of the container that contains it and is under low pressure.
2- Collisions between gas molecules are elastic.
3- The movement of gas molecules is random in the absence of an external influence.
4- The internal energy of the gas is zero.
5- The ratio of PV/T is constant at all pressure and temperature values.

6- It cannot be liquefied no matter how high the pressure applied to it or how low its temperature



Al-Mustaqbal University
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Second Stage

Difference between Ideal gas and Real gas

Ideal gas	Real gas
Ideal gas has no definite volume	Real gas has definite volume
It always Obey PV = nRT	It always Obeys p + ((n2 a)/V2)(V – n b) = nRT modified form of PV = nRT
particles of ideal gas have Elastic collision between molecules	particles of real gas have Non-elastic collisions between molecules
intermolecular attraction forces do not present between molecules	Intermolecular attraction forces present between molecules of gas.
It is a hypothetical gas that do not really exist in the environment.	Not a hypothetical gas that really exist in our environment.
Exist a High pressure	As compared to Ideal gas, The pressure is less.
Independent of factors like temperature, pressure and other gases.	Interacts with other gas and highly dependent.

Equation of State

Any equation that relates the pressure, temperature and volume of a substance is called an equation of state. Property relations that involve other properties of a substance at equilibrium states are also referred to as equations of state. There are several equations of state, some simple and others very complex. The simplest and best known equation of state for substances in the gas phase is the ideal gas equation of state. This equation predicts the (P-V-T) behavior of a gas quite accurately within some properly selected region. The ideal gas equation of state is expressed as :

$$PV = nRT$$

or $PV = RT$ (in terms of specific volume)

- **P** is the pressure of the ideal gas.
- **V** is the volume of the ideal gas.
- **n** is the amount of ideal gas measured in terms of moles.
- **R** is the gas constant.
- **T** is the temperature.

R is the gas constant, which has a different value for each gas and can be describe as the equation :

R=NA . KB

where : **KB** is Boltzmann's constant and NA is Avogadro's number then :

$$PV = nRT = N_A\, k_B\, T$$

There are the most common sets of units:

- **R** is (8.314 J·K−1 ·mol−1) Or (0.08206 L atm . K−1 ·mol−1)
- **P** is in pascals (Pa)
- **V** is in cubic meters (m3)
- **n** is in moles (mol)
- **T** is in kelvin (K)

Many scientists have studied the relationship between pressure, volume and temperature and have established many laws that determine the nature of the relationship between these properties. The most important of these laws are:

Boyle’s law states that the pressure of a given mass of an ideal gas is inversely proportional to its volume at a constant temperature. It is expressed as:

$$PV = C \text{ or } P_1V_1 = P_2V_2$$

Charles's law states that the volume of an ideal gas at constant pressure is directly proportional to the absolute temperature. It is expressed as:

$$V\ T = C \text{ or } V_1 T_1 = V_2 T_2$$

Gay-Lussac's law states that, for a given mass and constant volume of an ideal gas, the pressure exerted on the sides of its container is directly proportional to its absolute temperature. It is expressed as:

$$P\ T = C \text{ or } P_1 T_1 = P_2 T_2$$

From the previous relationships between pressure, volume and temperature, we find that:

Example1 An amount of gas has a pressure of 350 KPa, a volume of 0.03 m^3 and a temperature of 35°C. If R = 0.29 kJ/kg .K, calculate the mass of the gas and the final temperature if the final pressure is 1.05 MPa and the volume remains constant?

Solution:

The absolute temperature: $T\ 1 = 35 + 273 = 308$ K Applying the equation of state for the initial conditions: $P\ 1V\ 1 = m\ R\ T\ 1 = 350 \times 0.03 = m \times 0.29 \times 308 \rightarrow m = 350 \times 0.03/ (0.29 \times 308)$

$$\boldsymbol{m = 0.12\ \text{kg}}$$

Applying the equation of state between two conditions at constant volume:

$P_1/ T_1 = P_2/ T_2$

$= 350 /308 = (1.05 \times 10^3 / T_2) \rightarrow T_2 = (1.05 \times 10^3 \times 308) / 350$

$$\boldsymbol{T2 = 924}\ \text{K}$$

Example 2

5 moles of nitrogen gas is in a 100 liter fixed cylinder at 300 Kelvin. What is the pressure of the gas?

- P = ?
- V = 100 L
- n = 5 moles
- R = 0.08205 L·atm / mole·K
- T = 300 K

Alright, so let's begin with formula $PV = nRT$ and change that appropriately so it now is $P = nRT/V$. Now we can plug in the values to determine the pressure. We get:

$$P = \frac{(5\ moles)\left(0.08205\ \frac{L\cdot atm}{mol\cdot K}\right)(300\ K)}{100\ L}$$

$$P \approx 1.23\ atm$$

Example 3

Determine the volume of occupied by 2.34 grams of carbon dioxide gas at STP.

Solution:

PV = n R T and V = n RT / P

$V = [(2.34\ g / 44.0\ g\ mol^{-1})\ (0.08206\ L\ atm\ mol^{-1}\ K^{-1})\ (273.0\ K)] / 1.00\ atm$

V = 1.19 L

Questions

1-What is the definition of a real gas?

a) A gas that obeys the ideal gas laws under all conditions.
b) A gas that has no mass or volume.
c) A gas that deviates from ideal behavior at standard pressure and temperature.
d) A gas that is always in a solid state.
e) A gas that has no velocity.

2-Which of the following gases is considered a real gas?

a) Neon b) Oxygen c) Helium d) Argon e) Nitrogen

3-Which of the following is NOT an assumption of the ideal gas model?

a) Gas molecules are point-like.
b) There are no interactions between gas molecules. c) Gas molecules have volume.
d) The volume of the gas molecules is negligible compared to the container's volume. e) Collisions between gas molecules are elastic.

4-Which of the following gases behaves most closely to an ideal gas?

a) Carbon dioxide b) Hydrogen c) Oxygen d) Methane e) Ammonia

5-The equation of state for an ideal gas is given by:

a) PV = n R T b) P = VRT c) PV = n R/T
d) V = n R T/P e) P = n RT/V

/-Gay-Lussac’s law states that for a given mass and constant volume of an ideal gas, the pressure is directly proportional to:

a) Volume. b) Absolute temperature. c) The number of moles.
d) The molecular weight. e) The density.

Which of the following is the ideal gas equation expressed in terms of specific volume?

a) PV = RT b) PV = n RT c) PV = N_k BT
d) PV = R(T/V) e) PV = n R(T/V)