Department of Mining Engineering
-2nd-Class
College of Petroleum and Mining Engineering
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Thermodynamics
Lecture 2
The Ideal-Gas Equation of State

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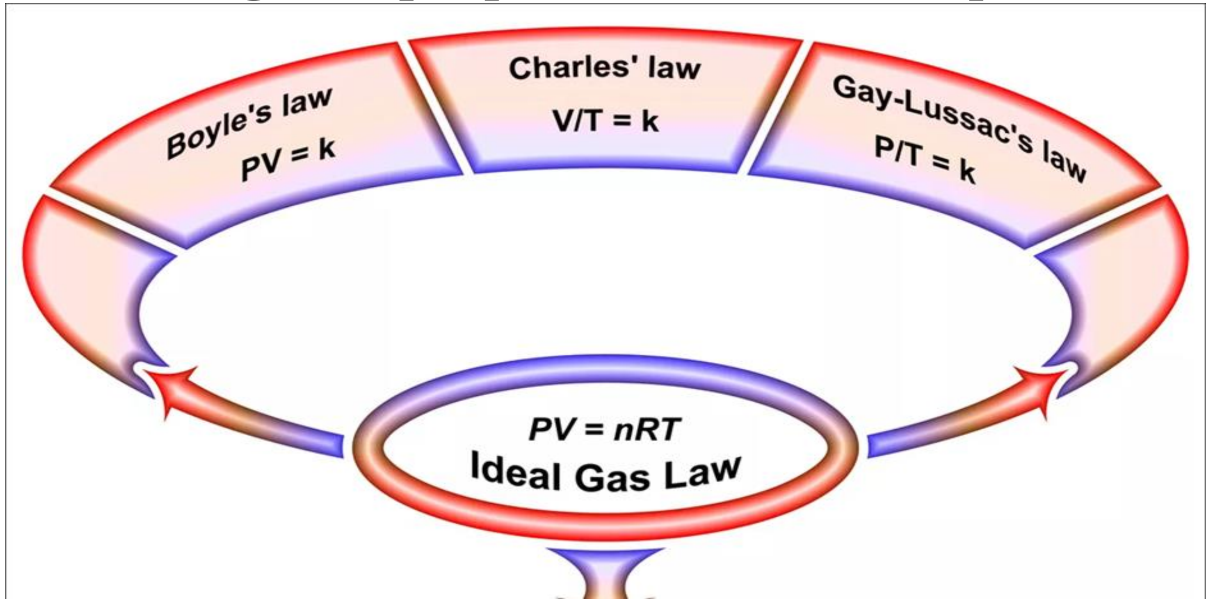
The Ideal-Gas (Equation of State)

- Any equation that relates the pressure, temperature, and specific volume of a substance is called an equation of state.

- In 1662, Robert Boyle observed during his experiments with a vacuum chamber that the pressure of gases is inversely proportional to their volume. In 1802, J. Charles and J. Gay-Lussac experimentally determined that at low pressures the volume of a gas is proportional to its temperature.



Boyle's Law

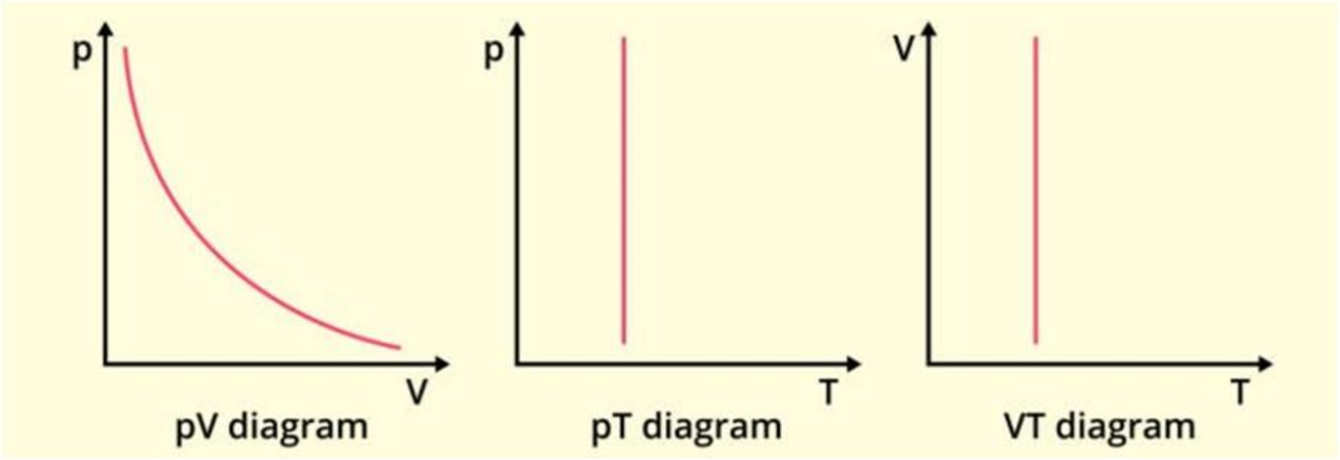
This law describes the inversely proportional relationship between absolute pressure and volume at a constant temperature for a fixed amount of gas.

$$V \propto \frac{1}{P}$$

$$V = \frac{c}{P}$$

$$\therefore PV = c$$

$$\therefore P_1V_1 = P_2V_2 = PV = constant$$



Charles's Law

This law describes the directly proportional relationship between the volume and temperature at a constant pressure for a fixed amount of gas.

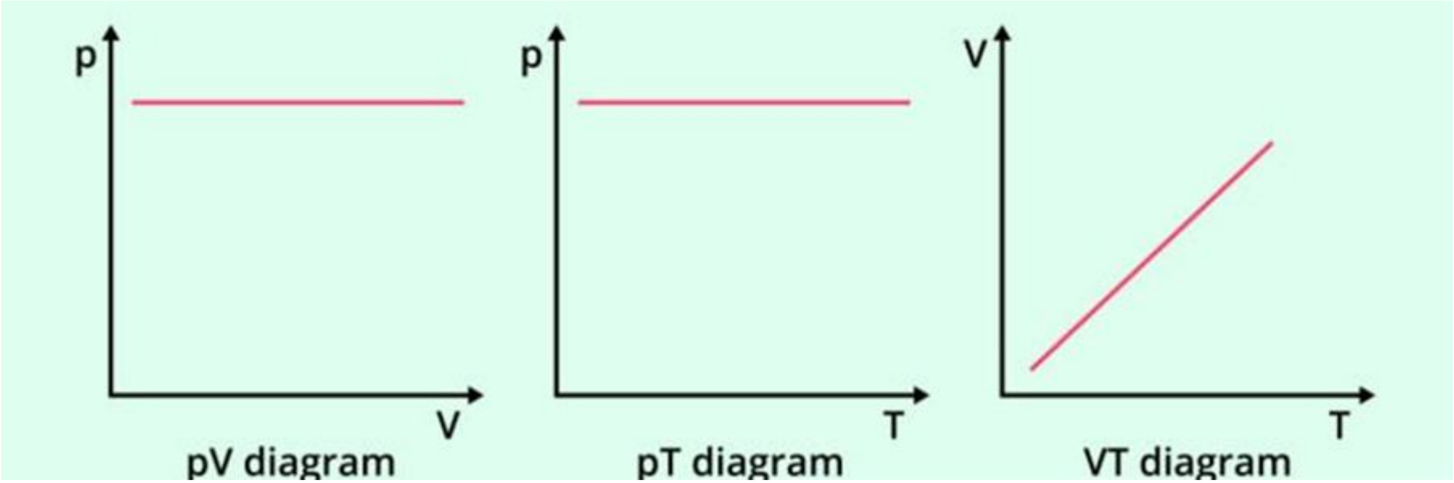
$$V \propto T$$

$$V = cT$$

$$\therefore \frac{V}{T} = c \quad or \quad \frac{T}{V} = c$$

$$\therefore \frac{V_1}{T_1} = \frac{V_2}{T_2} = \frac{V}{T} = constant$$

$$or \quad \frac{T_1}{V_1} = \frac{T_2}{V_2} = \frac{T}{V} = constant$$



Gay-Lussac's Law

This law describes the directly proportional relationship between the absolute pressure and temperature at a constant volume for a fixed amount of gas.

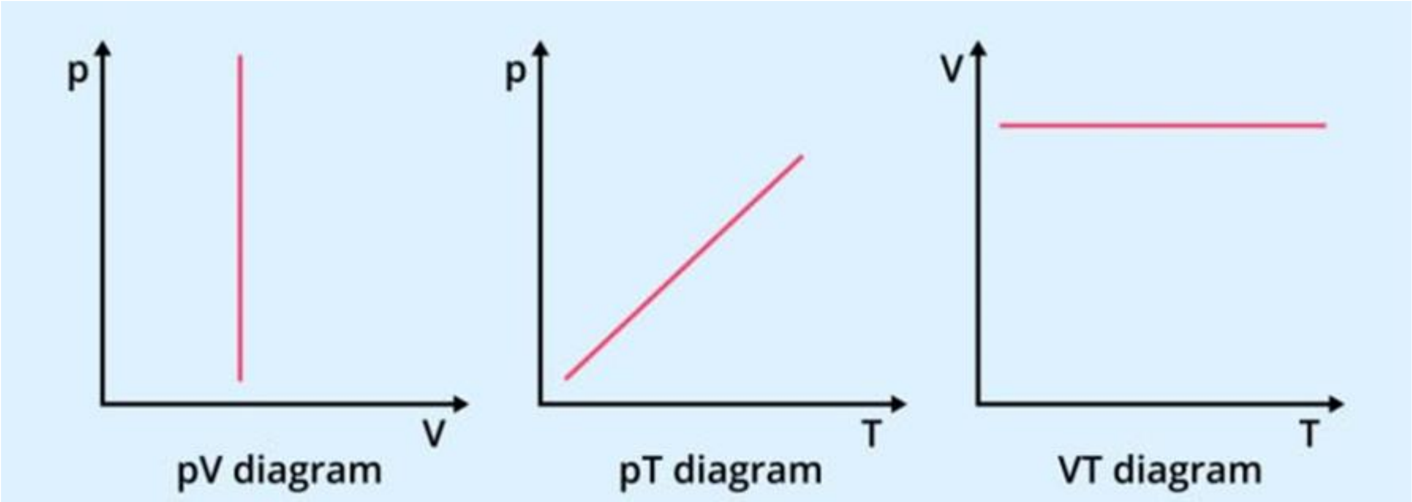
$$P \propto T$$

$$P = cT$$

$$\therefore \frac{P}{T} = c \quad or \quad \frac{T}{P} = c$$

$$\therefore \frac{P_1}{T_1} = \frac{P_2}{T_2} = \frac{P}{T} = constant$$

$$or \ \frac{T_1}{P_1} = \frac{T_2}{P_2} = \frac{T}{P} = constant$$



Ideal Gas Law

Experimental observations it has been established that an ideal gas behaves according to the simple equation:

$$PV = mRT$$

where:

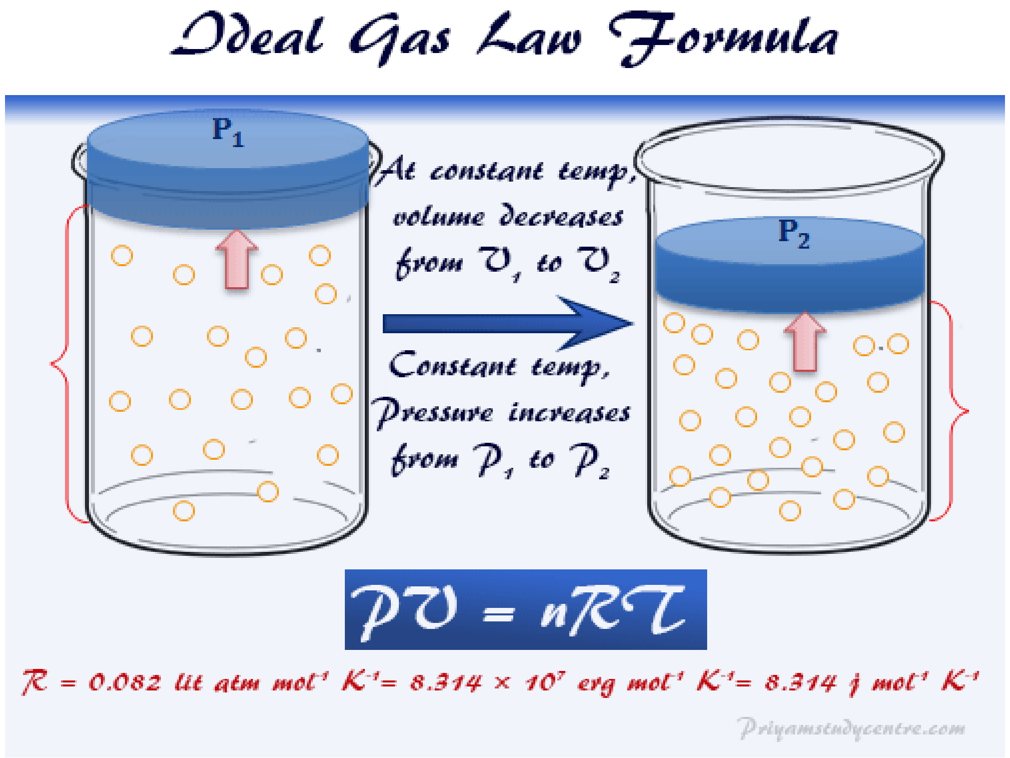
$P: Absolute\ Pressure\ of\ gas\ (pa)\left(\frac{N}{m^2}\right)$

$V: Volume\ of\ gas\ (m^3)$

$m: Mass\ of\ gas\ (kg)$

$R: Gas\ constant\ \left(\frac{J}{kg\ K}\right)$

$T: Temperature\ of\ gas\ (K)$



Ex (1): If the density of the hydrogen is 0.0897 kg/m^3 at 0 °C and pressure of 1.01325 bar, Calculate the value of the gas constant.

Ex (2): Calculate the volume of 3 kg of gas at a pressure of 1.6 bar and Temperature of 40 °C. Suppose the gas is heated under constant volume until its pressure reaches 2 bar. Calculate the final temperature.
Take the gas constant (R=190 J/kg K)

<u>Ex (3):</u> A cylinder contains 3.14 kg of Oxygen at 4.9 bar and temperature of 27 °C, Determine the initial volume of the cylinder and its capacity to contain this mass at one atmospheric and 20 °C. Take the gas constant (R=259.8 J/kg K)

Ex (4): A tank contains 1.4 m^3 of air at a pressure of 10.35 bar and temperature of 24 °C. Air is drawn off until the pressure is 5.5 bar and the temperature drops to 15 °C. Determine the mass of the air drawn off. For air take R=0.287 kJ/kg K

Ex (5): A tank contains 1.4 m3 of air at a pressure of 10.35 bar and temperature of 24°C. Air is added to the tank until the pressure is 13.5 bar and the temperature reaches to 29 °C. Determine the mass of air added. For air take (R=0.287 kJ/kg K)

Thank you for listening