dP in terms of β and κ

- Consider an infinitesimal change in P:

$$dP = \left(\frac{\partial P}{\partial T}\right)_V dT + \left(\frac{\partial P}{\partial V}\right)_T dV$$

- Then, dP is expressed as

$$dP = \frac{\beta}{\kappa} dT - \frac{1}{\kappa V} dV$$

  - Changes in pressure (dP), temperature (dT) and volume (dV) are related by β and κ

Calculation of compression in mercury when temperature rises at constant volume according to the relation:

$$\mathrm{d}P = \frac{\beta}{\kappa}\mathrm{d}T - \frac{1}{\kappa V}\mathrm{d}V$$

For example consider the case in

following problem. A mass of mercury at standard atmospheric pressure and a temperature of 15°C is kept at constant volume. If the temperature is raised to 25°C, what will be the final pressure? From tables of physical constants, β and κ of mercury remain practically constant within the temperature range of 15 to 25°C and have the values

$$\beta = 1.81 \times 10^{\ 4}\,\mathrm{K}^{-1},$$

and

$$\kappa = 4.01 \times 10^{-11}\,\mathrm{Pa}^{-1};$$

In this case dV=0 , then we have:

$$\mathrm{d}P = \frac{\beta}{\kappa}\mathrm{d}T - \frac{1}{\kappa V}\mathrm{d}V \rightarrow$$

$$\int_{P_\mathrm{i}}^{P_\mathrm{f}} \mathrm{d}P = \int_{T_\mathrm{i}}^{T_\mathrm{f}} \frac{\beta}{\kappa}\mathrm{d}T$$

$$P_\mathrm{f} - P_\mathrm{i} = \frac{\beta}{\kappa}\left(T_\mathrm{f} - T_\mathrm{i}\right) = \frac{\beta}{\kappa}10^{\circ}\mathrm{C} = \ldots 4.51\times10^{7}\,\mathrm{Pa!!}$$

Non Ideal gas Equation of State

- There are many equations of state that have been recommended for use to account for non ideal-gas behavior. Such behavior occurs where the pressure is relatively high (> 4 MPa for many gases) or when the temperature is near the saturation temperature.

There are no acceptable criteria that can be used to determine if the ideal-gas equation can be used or if the no ideal-gas equations of this section must be used. Usually a problem is stated in such a way that it is obvious that non ideal-gas effects must be included; otherwise a problem is solved assuming an ideal gas.

The *van der Waals equation of state is intended to account for the volume occupied by the gas* molecules and for the attractive forces between molecules. It is:

$$P = \frac{RT}{v-b} - \frac{a}{v^2}$$

These constants (a, b) are presented in the following Table to simplify calculations:

	a, kPa * m6/kg2	b, m3/kg
Air	0.1630	0.00127 870
Ammonia	1.468	0.00220
Carbon Dioxide	0.1883	0.000972
Freon	12 0.0718	0.000803
Helium	0.214	0.00587
Hydrogen	6.083	0.0132
Methane	0.888	0.00266
Nitrogen	0.1747	0.00138
Oxygen	0.1344	0.000993
Propane	0.481	0.00204 258
Water	1.703	0.00169 9

An improved equation for non ideal gases is the Redlich-Kwong equation of state:

$$P = \frac{RT}{v-b} - \frac{a}{v(v+b)\sqrt{T}}$$

These constants (a, b) are also presented in the following Table to simplify calculations:

	a, kPa - m6 - K1I2/kg2	b, m3/kg
Air	1.905	0.000878
Ammonia	30.0	0.00152
Carbon Dioxide	3.33	0.000674
Carbon Monoxide	2.20	0.000978
Freon	1.43	0.00055 7
Helium	0.495	0.00407
Hydrogen	35.5	0.00916
Methane	12.43	0.00184
Nitrogen	1.99	0.000957
Oxygen	1.69	0.000689
Propane	9.37	0.00141
Water	43.9	0.001 17