

PVT Behavior of Pure Substances

, P,T V

가 . . .

$f(T,P,V) = 0$

EOS(Equation of state)

가 (Ideal Gas)

$P = f(V,T)$

가

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

$\rightarrow \ln \frac{V_2}{V_1} = \beta(T_2 - T_1) - \kappa(P_2 - P_1)$

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

β =Volume expansivity

κ =Isothermal compressibility

Virial Equations

가 Virial Equation

Cubic Eos(Equation of state)

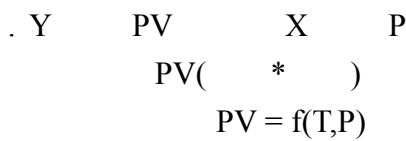
Virial Equation

Virial Equation

Virial Equation

Thermodynamic temperature

Fig. 3.5



$PV = a (1 + bP + cP^2 + dP^3 + \dots)$

a , b, c ,d

$0 \quad PV = (PV)^* \quad (PV)^* = a$ 가

가 . 1 $(PV)^* = a = R \cdot T$ 가

가 . 2

$(PV)^{*t} = 273.16 \cdot R$

$$T/K = 273.16 + (PV)^* / (PV)^*t$$

T ideal gas temperature scale
 constant $R = (PV)^*t / 273.16$ 가 Universal gas

Virial Equation

$$PV = RT (1 + bP + cP^2 + dP^3 + \dots)$$

$$Z = PV/RT = 1 + bP + cP^2 + dP^3 + \dots$$

$$= 1 + B/V + C/V^2 + D/V^3 + \dots$$

b B, c C, d D
 B C, D B interaction
 interaction C, D interaction
 가 , C

Ideal Gas

(Ideal Gas)
 가

- 1.
- 2.

interaction interaction
 가

가 가
 가 , 가

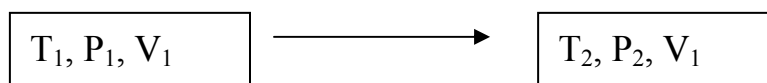
The Constant-Volume Process

가 가 가 T₁ T₂ ,

$$Q = \Delta U = \int_{T_1}^{T_2} C_V dT \quad \text{가}$$

$$\Delta U = \int_{T_1}^{T_2} C_V dT$$

C_V



가

$$\Delta U = \int_{T_1}^{T_2} C_V dT$$

The Constant-Pressure Process

가 T1 T2

$$Q = \Delta H = \int_{T_1}^{T_2} C_P dT \quad \text{가}$$

$$\Delta H = \int_{T_1}^{T_2} C_P dT \quad \text{가}$$

$$H=U+PV$$

$$PV=RT$$

$$H=U+RT \quad \text{가}$$

$$C_p = C_v + R$$

The Constant-Temperature(Isothermal) Process

가

가

$$dU = dW + dQ = 0$$

$$Q = -W \quad \text{가}$$

Q

$$Q = -W = RT \ln \frac{V_2}{V_1}$$

The Reversible Adiabatic Process

0

$$\gamma = \frac{C_P}{C_V} = \frac{C_V + R}{C_V}$$

$$W = \frac{P_2 V_2 - P_1 V_1}{\gamma - 1}$$

The Polytropic Process

4

Isobaric –

Isothermal –

Isochoric –

Adiabatic –

가

$$PV^a = K$$

$$a = 0 \quad P$$

$$a = 1 \quad PV \text{가}$$

$$a = r \quad PV^r$$

$$a = \quad V=0$$

가

$$W = \frac{RT_1}{\delta - 1} \left[\left(\frac{P_2}{P_1} \right)^{(\delta-1)/\delta} - 1 \right]$$

$$Q = \frac{(\delta - \gamma)RT_1}{(\delta - 1)(\gamma - 1)} \left[\left(\frac{P_2}{P_1} \right)^{(\delta - 1)/\delta} - 1 \right]$$

가
가 가
가

$$W_{\text{rev}} > W_{\text{irrev}} \text{ 가}$$

$$W_{\text{irrev}} > W_{\text{rev}} \text{ 가}$$

$$Y$$

$$W_{\text{irrev}} = Y * W_{\text{rev}} \text{ 가}$$

$$W_{\text{rev}} = Y * W_{\text{irrev}} \text{ 가}$$

Application of the Virial Equations

Virial Equation

Equation

Virial Equation

$$\left(\frac{dZ}{dP} \right)_{P=0} = B'$$

$$Z = 1 + B'P$$

$$Z = 1 + BP / RT = 1 + B/V$$

(Linear)

2

$$Z = 1 + B/V + C/V^2$$

Virial Equation

$$\frac{PV}{RT} = 1 + \frac{B}{V} + \frac{C}{V^2}$$

$$V_{i+1} = \frac{RT}{P} \left(1 + \frac{B}{V_i} + \frac{C}{V_i^2} \right)$$