

$$E(S, V)$$

$$W = E + PV$$

$$F = E - TS$$

$$\Phi = E + PV - TS$$

$$\rightarrow dE = TdS - PdV$$

$$dW = TdS + VdP$$

$$dF = -SdT - PdV$$

$$d\Phi = -SdT + VdP$$

$$\rightarrow dE = \frac{\partial E}{\partial S} dS + \frac{\partial E}{\partial V} dV$$

$$\frac{\partial E}{\partial S \partial V} = \frac{\partial E}{\partial V \partial S} \quad \text{Maxwell Rel.}$$

$$\left(\frac{\partial T}{\partial V} \right)_S = - \left(\frac{\partial P}{\partial S} \right)_V \quad (E)$$

$$\left(\frac{\partial T}{\partial P} \right)_S = \left(\frac{\partial V}{\partial S} \right)_P \quad (W)$$

$$\left(\frac{\partial S}{\partial V} \right)_T = \left(\frac{\partial P}{\partial T} \right)_V \quad (F)$$

$$\left(\frac{\partial S}{\partial P} \right)_T = - \left(\frac{\partial V}{\partial T} \right)_P \quad (\Phi)$$

Jacobians $u(x, y), v(x, y)$ (19)

$$\frac{\partial(u, v)}{\partial(x, y)} = \begin{vmatrix} \frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} \\ \frac{\partial v}{\partial x} & \frac{\partial v}{\partial y} \end{vmatrix}$$

$$\frac{\partial(u, v)}{\partial(x, y)} = - \frac{\partial(u, v)}{\partial(y, x)}$$

$$\frac{\partial(u, y)}{\partial(x, y)} = \left(\frac{\partial u}{\partial x} \right)_y$$

$$\frac{\partial(u, v)}{\partial(x, y)} = \frac{\partial(u, v)}{\partial(S, T)} \frac{\partial(S, T)}{\partial(x, y)}$$

applications

$$C_V = T \left(\frac{\partial S}{\partial T} \right)_V \Leftrightarrow C_P$$

$$\left(\frac{\partial S}{\partial T} \right)_V = \frac{\partial(S, V)}{\partial(T, V)} = \frac{\partial(S, V)}{\partial(T, P)} \frac{\partial(T, P)}{\partial(T, V)}$$

$$= \left[\left(\frac{\partial S}{\partial T} \right)_P \left(\frac{\partial P}{\partial T} \right)_V - \left(\frac{\partial S}{\partial P} \right)_T \left(\frac{\partial V}{\partial T} \right)_P \right] \left(\frac{\partial P}{\partial V} \right)_T$$

$$\left(\frac{\partial P}{\partial V} \right)_T = \left(\frac{\partial P}{\partial T} \right)_T \left(\frac{\partial T}{\partial V} \right)_T \rightarrow \left(\frac{\partial S}{\partial T} \right)_P = - \left(\frac{\partial V}{\partial T} \right)_P$$