$dU = đQ + đW$ 1st Law..

8

$= đQ - pdV$

9 $\Rightarrow đQ = dU + pdV$

10 $dS \geq \frac{đQ}{T}$

11

12 $\Rightarrow đQ \leq TdS$

1 $\Rightarrow TdS \geq dU + pdV$

2

3 For reversible process

4 $dU = TdS - pdV$

5 $\cancel{f = f(x, y)}$

6 $\cancel{df = \left(\frac{\partial f}{\partial x}\right) dx + \left(\frac{\partial f}{\partial y}\right) dy}$

x, y, z

$$x = x(y,z)$$

$$dx = \left(\frac{\partial x}{\partial y}\right)_z dy + \left(\frac{\partial x}{\partial z}\right)_y dz$$

$\cancel{z = z(x,y)}$ $z = z(x,y)$

$$dz = \left(\frac{\partial z}{\partial x}\right)_y dx + \left(\frac{\partial z}{\partial y}\right)_x dy$$

$$dx = \left(\frac{\partial x}{\partial z}\right)_y \left(\frac{\partial z}{\partial x}\right)_y dx + \left[\left(\frac{\partial x}{\partial y}\right)_z + \left(\frac{\partial x}{\partial z}\right)_y \left(\frac{\partial z}{\partial y}\right)_x\right] dy$$

$$\left(\frac{\partial x}{\partial z}\right)_y \left(\frac{\partial z}{\partial x}\right)_y = 1$$ Reciprocal Th.

$$\Rightarrow \left(\frac{\partial x}{\partial z}\right)_y = \frac{1}{\left(\frac{\partial z}{\partial x}\right)_y}$$

$$\left(\frac{\partial x}{\partial y}\right)_z + \left(\frac{\partial x}{\partial z}\right)_y \left(\frac{\partial z}{\partial y}\right)_x = 0.$$

$$\Rightarrow \left(\frac{\partial x}{\partial y}\right)_z \left(\frac{\partial y}{\partial z}\right)_x \left(\frac{\partial z}{\partial x}\right)_y = -1$$

$$f = f(x, y)$$

$$df = \left(\frac{\partial f}{\partial x}\right)_y dx + \left(\frac{\partial f}{\partial y}\right)_x dy$$

$$F_1 = \left(\frac{\partial f}{\partial x}\right)_y \qquad F_2 = \left(\frac{\partial f}{\partial y}\right)_x$$

$$\vec{F} = \vec{\nabla} f$$

$$\int_1^2 F_1(x,y)\,dx + F_2(x,y)\,dy = \int_1^2 \vec{F}\cdot d\vec{r}$$

$$\Rightarrow \oint df = \oint \vec{F}\cdot d\vec{r} = 0.$$

$$\Rightarrow \vec{\nabla}\times\vec{F} = 0.$$

$$\Rightarrow \left(\frac{\partial F_2}{\partial x}\right)_y = \left(\frac{\partial F_1}{\partial y}\right)_x$$

$$\Rightarrow \frac{\partial^2 f}{\partial x\,\partial y} = \frac{\partial^2 f}{\partial y\,\partial x}$$

$\Rightarrow$

Maxwell's Relation.

1. $$dU = TdS - PdV$$

$$U = U(S,V)$$

$$dU = \left(\frac{\partial U}{\partial S}\right)_V dS + \left(\frac{\partial U}{\partial V}\right)_S dV$$

$$\Rightarrow T = \left(\frac{\partial U}{\partial S}\right)_V \qquad P = -\left(\frac{\partial U}{\partial V}\right)_S$$

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

$$H = H(S,P)$$

2. $$dH = TdS + VdP \qquad T = \left(\frac{\partial H}{\partial S}\right)_P \Big/ V = \left(\frac{\partial H}{\partial P}\right)_S$$

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

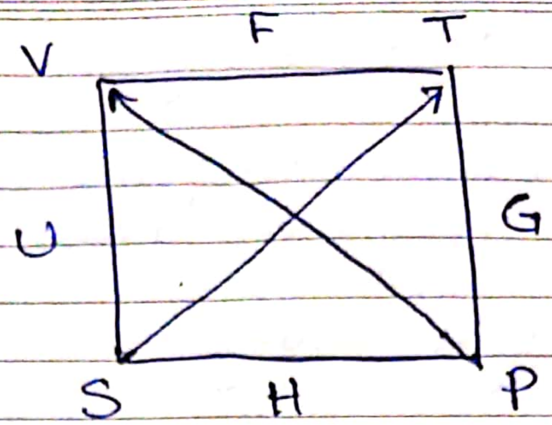
3. $$dF = -SdT - PdV$$

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

4. $$dG = -SdT + VdP$$

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

König-Born diagram



Valid Facts and Theoretical ~~Understant~~ Understanding Generate Solutions to Hard Problems

Good Physicist Have Studied Under Very Fine Teacher.

□ **Legendre Transformation:**

□ Transformation that converts a function of one set of variable to another set of conjugate variables.

$(x, y) \rightarrow$ Conjugate

$$d(x,y) = x\,dy + y\,dx$$

$$f = f(x,y)$$

$$df = \left(\frac{\partial f}{\partial x}\right)_y dx + \left(\frac{\partial f}{\partial y}\right)_x dy$$

$$= u\,dx + w\,dy$$

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

$w = \left(\frac{\partial f}{\partial y}\right)_x$.

$f = f(x, y)$

$df = u\,dx + w\,dy$;

u & x are conjugate pair
w & y are conjugate pair

$d(wy) = dw\,y + w\,dy$

$d(f - wy) = u\,dx - y\,dw$

$dg = u\,dx - y\,dw \qquad g = f - wy = g(x, w)$

$f(x,y) \longrightarrow g(x,w)$
$\qquad\searrow h(u,y)$
$\qquad\searrow k(u,w)$

$U = U(S, V)$

$dU = T\,dS - P\,dV$

$H = H(S, P)$

$\cancel{w = \frac{\partial f}{\partial y}}$

$\boxed{g = f - wy}$

$\Rightarrow H = U - (-P)V = U + PV$
$H(S, P)$

$\to f$
$\to x = S$

$u = \left(\frac{\partial f}{\partial x}\right)_y = \left(\frac{\partial U}{\partial S}\right)_V = T$

$y = V$

$w = \left(\frac{\partial f}{\partial y}\right)_x = \left(\frac{\partial U}{\partial V}\right)_S = -P$

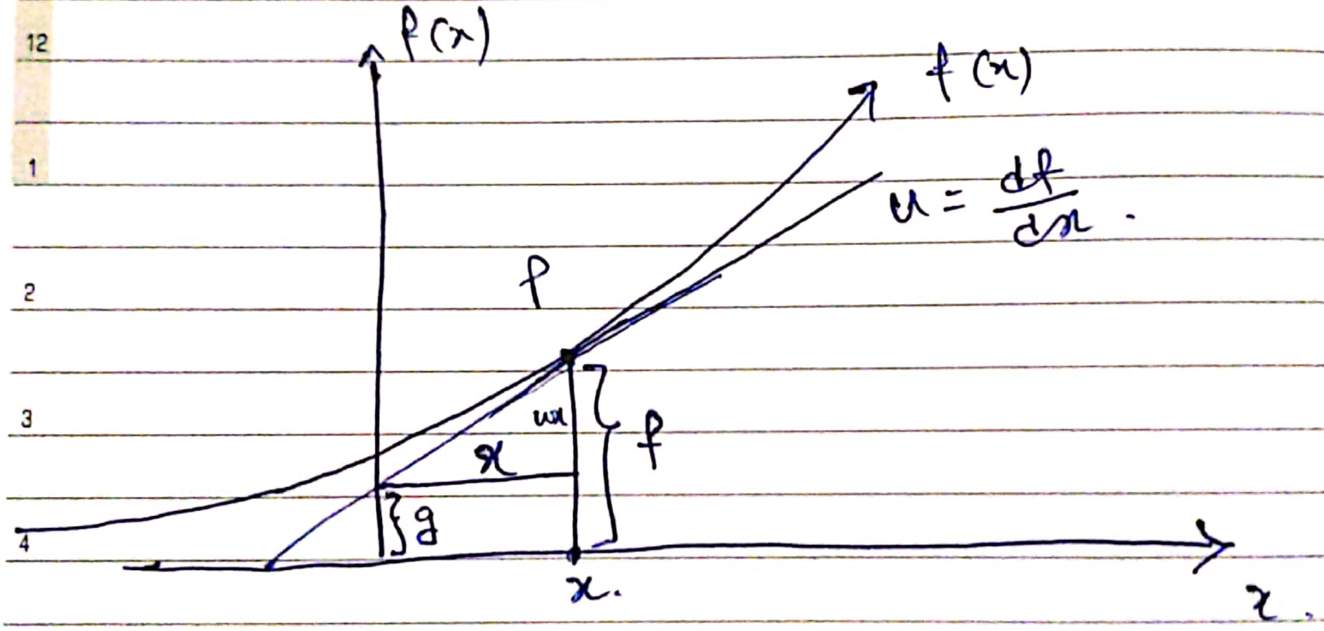
$$f = f(x) = e^{x-1}$$

$$u = \frac{df}{dx} = e^{x-1} \Rightarrow x = 1 + \ln u$$

$$g(u) = g = f(x) - xu$$

$$= u - (1 + \ln u)u$$

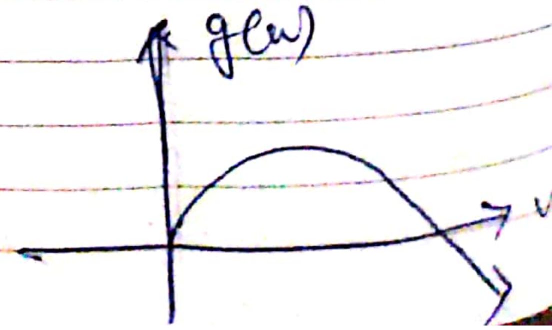
$$= -u \ln u$$



g = vertical intercept of slope.

$$g(0) = f(x)\Big|_{\frac{df}{dx}=0}$$

$$g(1) =$$



Single valued only for convex function.