Problems for Class and Homework

Dr. Addison

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In each of the following, assume that we are dealing with fixed amounts of pure substances so that we can write the fundamental thermodynamic identity as $dU = T dS - pdV$. you will find the following definitions to be useful:

$$\alpha = \frac{1}{V} \left( \frac{\partial V}{\partial T} \right)_p$$

$$\kappa = -\frac{1}{V} \left( \frac{\partial V}{\partial p} \right)_T$$

$$C = \frac{dQ}{dT}$$

$$C_p = \left( \frac{dQ}{dT} \right)_p = T \left( \frac{\partial U}{\partial T} \right)_p + p \left( \frac{\partial V}{\partial T} \right)_p = T \left( \frac{\partial S}{\partial T} \right)_p$$

$$C_V = \left( \frac{dQ}{dT} \right)_V = \left( \frac{\partial U}{\partial T} \right)_V = T \left( \frac{\partial S}{\partial T} \right)_V$$

HW 26. (2) Derive

$$U = F - T \left( \frac{\partial F}{\partial T} \right)_V = -T^2 \left( \frac{\partial F}{\partial T} \right)_V$$

HW 27. (1) Derive

$$C_V = -T \left( \frac{\partial^2 F}{\partial T^2} \right)_V$$

HW 28. (2) Derive

$$H = G - T \left( \frac{\partial G}{\partial T} \right)_p = -T^2 \left( \frac{\partial G}{\partial T} \right)_p$$

(This is called the Gibbs-Helmholtz equation)

HW 29. (1) Derive

$$C_p = -T \left( \frac{\partial^2 G}{\partial T^2} \right)_p$$

HW 30. (3) Derive the third $TdS$ equation

$$TdS = C_V \left( \frac{\partial T}{\partial p} \right)_V dp + C_p \left( \frac{\partial T}{\partial V} \right)_p dV.$$
Show that the three $T d S$ equations can be rewritten as

HW 31. (2)

$$T d S = C_V d T + \frac{\alpha T}{\kappa} d V$$

HW 32. (2)

$$T d S = C_p d T - V \alpha T d P$$

HW 33. (2)

$$T d S = \frac{C_V \kappa}{\alpha} d P + \frac{C_p}{\alpha V} d V$$

HW 34 (2) Defining the Massieu function $F_m$ by the equation $F_m = -\frac{U}{T} + S$ show that

$$d F_m = \frac{U}{T^2} d T + \frac{P}{T} d V.$$ 

HW 35 (2) Defining the Planck function $F_p$ by the equation $F_p = -\frac{H}{T} + S$ show that

$$d F_p = \frac{H}{T^2} d T - \frac{V}{T} d P.$$ 

Hw 36 (4) Problem 5-14 (a) to (e).

HW 37 (2) Problem 5-15

HW 38 (3) Problem 5-16

HW 39 (3) Problem 5-23 (a) to (c)