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 $\mathrm{d}U = T\mathrm{d}S - p\mathrm{d}V$. you will find the following definitions to be useful:

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

$$C = \frac{đQ}{đT}$$

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

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

HW 26. (2) Derive

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

HW 27. (1) Derive

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

HW 28. (2) Derive

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

(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 $T\mathrm{d}S$ equation

$$T\mathrm{d}S = C_V\left(\frac{\partial T}{\partial p}\right)_V \mathrm{d}p + C_p\left(\frac{\partial T}{\partial V}\right)_p \mathrm{d}V.$$

Show that the three $T\mathrm{d}S$ equations can be rewritten as

HW 31. (2)

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

HW 32. (2)

$$T\mathrm{d}S = C_p \mathrm{d}T - V\alpha T \mathrm{d}P$$

HW 33. (2)

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

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

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

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

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

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)