first law of thermodynamics

none

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Abstract

Generated by the Physics Derivation Graph. https://www.youtube.com/watch?v=QTiqF-HtkS0 and https://www.youtube.com/watch?v=3Yls-t3B49U

Eq. 1 is an initial equation.

$$U = Q + W \tag{1}$$

Eq. 2 is an initial equation. hold volume constant in first term; hold temperature constant in second term

$$dU = \left(\frac{\partial U}{\partial T}\right)_V dT + \left(\frac{\partial U}{\partial V}\right)_T dV \tag{2}$$

Eq. 3 is an initial equation.

$$S = k_{\text{Boltzmann}} \ln \Omega \tag{3}$$

Eq. 4 is an initial equation.

$$C_V = \left(\frac{\partial U}{\partial T}\right)_V \tag{4}$$

Eq. 5 is an initial equation.

$$\pi_T = \left(\frac{\partial U}{\partial V}\right)_T \tag{5}$$

Substitute LHS of Eq. 4 and LHS of Eq. 5 into Eq. 2; yields Eq. 6.

$$dU = C_V dT + \pi_T dV \tag{6}$$

Divide both sides of Eq. 6 by dT; yields Eq. 7.

$$\left(\frac{\partial U}{\partial T}\right)_p = C_V \left(\frac{\partial T}{\partial T}\right)_p + \pi_T \left(\frac{\partial V}{\partial T}\right)_p \tag{7}$$

Eq. 8 is an initial equation.

$$\alpha = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_p \tag{8}$$

Multiply both sides of Eq. 8 by V; yields Eq. 9.

$$V\alpha = \left(\frac{\partial V}{\partial T}\right)_p \tag{9}$$

Substitute LHS of Eq. 9 into Eq. 7; yields Eq. 10.

$$\left(\frac{\partial U}{\partial T}\right)_p = C_V \left(\frac{\partial T}{\partial T}\right)_p + \pi_T V \alpha \tag{10}$$

Simplify Eq. 10; yields Eq. 11.

$$\left(\frac{\partial U}{\partial T}\right)_p = C_V + \pi_T V \alpha \tag{11}$$

Eq. 12 is an initial equation.

$$\kappa_T = \frac{-1}{V}\left(\frac{\partial V}{\partial P}\right)_T \tag{12}$$

References