S. S. College. Jehanabad (Magadh University)

Department : Physics

Subject : Thermodynamics

Class : B.Sc(H) Physics Part I

Topic: Application of Maxwell’s Thermodynamical Relation

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Temperature Change in Adiabatic Process

From the first thermodynamical relation we have

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

Multiplying and dividing the right hand side of equation (i) by *T*, we get

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

$$T.\partial S = \partial Q,$$

Substituting in equation (ii) we have

$$= -T\left(\frac{\partial P}{\partial Q}\right)_V \quad \text{................. (iii)}$$

An increase in amount of heat (δQ) at constant volume results in an increase in pressure of the gas. $\left(\frac{\partial P}{\partial Q}\right)_V$ is always positive. Hence the term $\left(\frac{\partial T}{\partial V}\right)_S$ will always be negative. Which implies that the temperature will decrease with an increase in volume when entropy remains constant (the process being adiabatic). Thus *adiabatic expansion results in a fall of temperature* of the gas.

From the third thermodynamical relation we have

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

Multiplying and dividing equation (iv) by T we have

$$\left(\frac{\partial T}{\partial P}\right)_S = T\left(\frac{\partial V}{T\partial S}\right)_P \quad \text{……………. (v)}$$

Using.

$$T.\partial S = \partial Q,$$

Substituting in equation (v) we get

$$= T\left(\frac{\partial V}{\partial Q}\right)_P \quad \text{...(vi)}$$

Since, an increase in the quantity heat (∂Q) at constant pressure, always results in an increase in the volume. The term $\left(\frac{\partial V}{\partial Q}\right)_P$ will be positive, hence the term $\left(\frac{\partial T}{\partial P}\right)_S$ must also be positive and the temperature must increase with increase in pressure of the gas at constant entropy (*when the process is* adiabatic process). Thus, *an adiabatic compression must result in an increase in temperature of the gas.*