Thermal Physics, Autumn 2016 CMI

Problem set 2

Due by the beginning of lecture on Monday, Aug 29, 2016

First Law of Thermodynamics

1. $\langle \mathbf{2} \rangle$ Taking p and V as independent variables, use the first law of thermodynamics to obtain an expression for the infinitesimal heat δQ added reversibly to a fixed mass of a gas. We do not assume the gas to be ideal.

2. $\langle \mathbf{5} \rangle$ Use the first law to show that the difference in heat capacities is given by

$$C_p - C_V = \left(\left(\frac{\partial U}{\partial V} \right)_T + p \right) \left(\frac{\partial V}{\partial T} \right)_p . \tag{1}$$

3. $\langle \mathbf{2} \rangle$ Now suppose a gas satisfies the ideal equation of state $pV = nRT$ and the 'Caloric condition' $\left(\frac{\partial U}{\partial V}\right)_T = 0$. Evaluate the difference $C_p - C_V$ for such an ideal gas.

4. $\langle \mathbf{4} \rangle$ Suppose a fixed mass of a gas with heat capacity at constant volume $C_V(T)$ is reversibly heated at constant volume from state (T_1, p_1) to a state (T_2, p_2). Find expressions for the work done by the gas ΔW, heat added to the gas ΔQ and increase in internal energy of the gas ΔU.