PH421 - Thermal and Statistical Physics

Assignment 8 - Feb 27, 2008

1. A heat engine operated by two real heat baths

Two identical bodies are characterized by a heat capacity at constant pressure C, which is independent of temperature. They are used as heat baths for a heat engine, and remain at constant pressure throughout their use. After operating the engine, the initial temperatures of the two bodies (T_1 and T_2) attain a common final value T_f. At that point, the engine stops its operations.

(a) Find the totla amount of work done by the engine in terms of C, T_1, T_2 and T_f.

(b) Derive an inequality abong T_1, T_2 and T_f.

(c) For a given set of values for T_1 and T_2, find the maximum amount of work obtainable from this engine.

2. Problem 5.6. Note that the Joule-Thomson process was not studied in class. For this problem, it suffices to know that the process is isothermal for an ideal gas.

3. The Otto cycle

The *Otto* cycle is an idealization of a real combustion engine cycle. The cycle is composed of the following steps:

(1) An adiabatic compression;

(2) An increase in pressure at constant volume, representative of the pressure increase due to the explosion of the mixture. In this step, the engine acquires an amount Q_1 of heat.

(3) Ad adiabatic expansion, where the engine does positive work;

(4) Pressure decrease at constant volume, representative of the cooling of the gas. During this step, the engine releases an amount Q_2 of heat.

Assume that the cycle is performed by an ideal gas, and that the process is quasi-static.

(a) Draw the cycle in a $p - V$ plane, and in a $S - T$ plane.

(b) The efficiency of this engine is given by

$$\eta = \frac{W}{Q_1} \tag{1}$$

Find the efficiency in terms of the volumes V_1 and V_2 between which the engine operates, and of the ratio of specific heats $\gamma = C_P/C_V$.