

## J05T.3 - Thermodynamic Variables

### Problem

A thermodynamic system has the following relation between its entropy  $S$ , volume  $V$ , internal energy  $U$ , and particle number  $N$ :

$$S(U, V, N) = \gamma(UVN)^{1/3},$$

where  $\gamma$  is a constant.

- a) Derive a relation connecting  $U, N, V$  and the temperature  $T$ .
- b) Find the heat capacity  $C_{VN}$  at constant  $V$  and  $N$ , as a function of  $V, N$ , and temperature  $T$ .

Now assume you are given two identical bodies with the above properties.  $N$  and  $V$  are the same for both, and are fixed, but the two bodies have different initial temperatures,  $T_1$  and  $T_2$ .

- c) If the two bodies are placed in thermal contact, and left alone until heat flow ceases and equilibrium is reached, what is their common final temperature  $T_f$ ?
- d) If the flow of heat between the bodies is used to drive an engine that does the maximum possible amount of useful work  $W_{max}$  before the two bodies reach a common final temperature  $T'_f$ , what is that temperature? What is  $W_{max}$ ?