1. An engine is represented by the cyclic transformation shown in the $\sigma - \tau$ diagram. Here, $A$ denotes the area of the shaded region and $B$ the area of the region below it. Show that this engine is not as efficient as a Carnot engine operating between the highest and lowest available temperatures (6 pt). Show that an arbitrary reversible engine cannot be more efficient than a Carnot engine operating between the highest and the lowest available temperatures (7 pt).

[Diagram showing $\sigma - \tau$ diagram with shaded region A and unshaded region B.]

2. Chapter 8, p. 259, problem 10 (6 pt). Expansion into vacuum is irreversible, pressure is equal to zero.

3. Chapter 9, p. 272, problem 1 (6 pt)

You need to have 20 points out of 25 (5 points are extra credit).

The problems are from Kittel & Kroemer, *Thermal Physics*, 2nd edition, (Freeman, NY 1980).