AREN 2110
2nd Law Extra Credit Problems

Solutions
Name

Answer the 10 multiple-choice questions by circling the best choice Justify all answers. If you do, partial credit will be given for a good attempt to analyze the question even if the answer is incorrect. If you don't, no credit given for right answer and no explanation.

1. According to the 1st Law of Thermodynamics, the maximum efficiency of a heat engine could be - justify your answer -:

   a) 1 (circled)
   b) $1-\frac{Q_{out}}{Q_{in}}$
   c) $1-\frac{T_L}{T_H}$
   d) none of the above

   $Q_{net} = W_{net}$ where Q_L could $= 0$

2. It is impossible for a process that is adiabatic to be $Q = 0$

   a) reversible and isentropic — $S_2 - S_1 = S_{gen}$ ok
   b) isothermal and reversible — example: pump ok
   c) irreversible and isentropic (circled) — $S_{gen} > 0$ so $S_2 > S_1$ not $S_2 = S_1$
   d) irreversible — $S_2 > S_1$ ok

3. The process of saturated steam condensing to saturated liquid at constant pressure in a heat exchanger cannot be - choose one and justify your answer:

   a) irreversible — $S_2 - S_1 = \frac{Q}{T} + S_{gen}$
   b) reversible — $S_2 < S_1$ since $S_f < S_g$ @ same T, P
   c) isentropic (circled)
   d) isothermal

4. Any **adiabatic and reversible** unit process is always:

   a) isochoric
   b) isentropic (circled)
   c) isobaric
   d) isothermal
   e) isolatent
   f) isometric

   $S_2 - S_1 = \frac{Q}{T}^{0} + S_{gen}^{0}$

5. Clausius found that for any heat engine cycle the **ratio**:

$\oint \left(\frac{Q}{T}\right)_k \leq 0$

a) Heat Transferred:Absolute Temperature of the Surroundings = 0

b). Heat Transferred:Absolute Temperature of the Surroundings < 0

c) Heat Transferred:Absolute Temperature of the Surroundings > 0

d) Heat Transferred:Absolute Temperature of the Surroundings ≤ 0

e) Heat Transferred:Absolute Temperature of the Surroundings ≥ 0

6. Steam is expanded in a **reversible** turbine which loses heat to the surroundings. The entropy of the steam will always

$\dot{m}(s_2 - s_1) = \frac{\dot{Q}}{T} + \dot{S}_{gen}$ ($\dot{S}_{gen} = 0$, $\dot{Q}$ is $-$)

so $s_2 < s_1$

a) Increase in proportion to heat transferred

b) Stay the same

c) Decrease in proportion to heat transferred

d) Cannot be determined

e) Equal the entropy generated in the surroundings

f) Decrease in proportion to the work produced

7. The coefficient of performance of a Carnot heat pump is:

a) always greater than the coefficient of performance of a Carnot refrigerator for the same T_H and T_L

b) always less than the coefficient of performance of a Carnot refrigerator for the same T_H and T_L

c) always equal to the coefficient of performance of a Carnot refrigerator for the same T_H and T_L

d) always equal to the efficiency of a Carnot heat engine for the same T_H and T_L

e) dependent only on the work input

f) dependent only on the capacity to reject heat to the high temperature reservoir

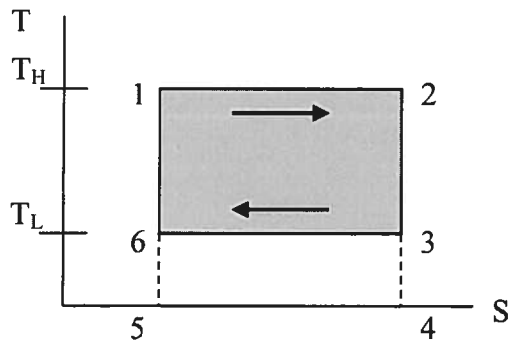
$COP_{HP} = COP_R + 1$

8. For which type of process is the equation dQ = Tds valid?

(a) irreversible (b) isothermal (c) reversible (d) isobaric

CLAUSIUS PRINCIPLE

9. An ideal reversible Carnot cycle is represented on the T-S diagram below. The efficiency of the cycle is represented by which of the following ratios of areas?



$$\eta = \frac{W_{net}}{Q_H} = \frac{Q_{net}}{Q_H} = \frac{1-2-3-6}{1-2-4-5}$$

(a) $\frac{1-2-3-6}{1-2-4-5}$ (b) $\frac{1-2-4-5}{1-2-3-6}$ (c) $\frac{3-4-5-6}{1-2-4-5}$ (d) $\frac{1-2-4-5}{3-4-5-6}$

10. Heat is rejected to a single reservoir with absolute temperature = T during a real condensation process. According to the 2nd Law of Thermodynamics:

a) S_{gen} must = 0 (x irrev.)

b) $\left|\frac{Q}{T}\right| = |S_2 - S_1|$

c) $\left|\frac{Q}{T}\right| < |S_2 - S_1|$

d) $\left|\frac{Q}{T}\right| > |S_2 - S_1|$

e) none of the above

$$S_2 - S_1 = \frac{Q}{T} + S_{gen}$$

$$S_2 - S_1 - \frac{Q}{T} = S_{gen}$$

$S_{liq} < S_{vapor}$

$S_2 < S_1$ and $\frac{Q}{T} < 0$ (heat out)

$(-)$ $(-)$

so $\left|\frac{Q}{T}\right| > |S_2 - S_1|$