Physics 122-01

Test 1

February 23, 2005

Name:____

Start all problems with a fundamental principle or with an equation from the equation sheet. Be sure to show your work **clearly** and **draw a box around your answer**. If any question is unclear, please ask immediately.

1. (30 pts.) As part of the design for a new residence hall, a physics professor proposes to use an ideal heat pump. The outside temperature is -5.0° C, and the temperature inside the building is to be maintained at 22° C. In order to maintain that internal temperature, heat must be supplied to the building at a rate of 2,000 Watts.

   a. (20 pts.) What is the rate at which work must be done on the heat pump?

   b. (10 pts.) What is the rate at which this heat pump is increasing the entropy of the universe?

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Name: SOLUTIONS

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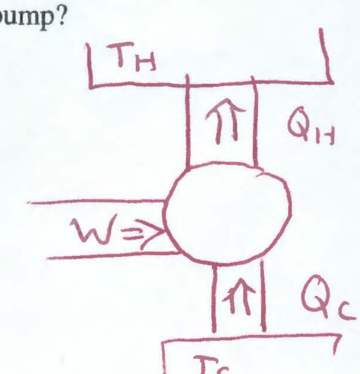
   a. (20 pts.) What is the rate at which work must be done on the heat pump?

$T_C = -5 + 273.15 = 268.15\,K$

$T_H = 22 + 273.15 = 295.15\,K$

want $\frac{dQ_H}{dt} = 2000\,W.$

$K_{carnot} = \frac{T_C}{T_H - T_C} = 9.93$



$|Q_C| + |W| = |Q_H|$

but $K = \frac{|Q_C|}{|W|} = \frac{|Q_H| - |W|}{|W|} = \left|\frac{Q_H}{W}\right| - 1$

$\therefore \frac{|Q_H|}{|W|} = K + 1 = 10.93$

$|W| = \frac{|Q_H|}{10.93}$

$\frac{d|W|}{dt} = \frac{d|Q_H|/dt}{10.93} = \frac{2000}{10.93} = \boxed{183\,W}$

   b. (10 pts.) What is the rate at which this heat pump is increasing the entropy of the universe? $\boxed{0,}$ since it's ideal. If you wish to prove it:

$\Delta S = \Delta S_C + \Delta S_H = \frac{-Q_C}{T_C} + \frac{Q_H}{T_H} = 0$ since this is a Carnot cycle.

$\frac{d(\Delta S)}{dt} = \frac{-dQ_C}{dt}\Big/T_C + \frac{dQ_H}{dt}\Big/T_H = -\frac{(2000-183)}{268.15} + \frac{2000}{295.15} = 0.$