Thermodynamics Pre-Nationals Exam I:

Show work, as partial credit may be given. However, full credit will be given if the answer is right, even if no work is shown. There are 56 possible points.

1) A body of ideal gas exists at a certain temperature, pressure, and volume, inside of a fiction-less, mass-less piston, inside of an arbitrarily large water bath at 25°C. Weights are placed on the piston to increase the pressure on the gas. How does this affect a) the internal energy and b) the enthalpy of the gas? **[4]**

2) Express the heat approximate molar specific heat (units J K^{-1} mol^{-1}) of most solids in terms of R. The constancy of this value is state by what law, named after a "small" man and his coworker. [4]

3) In terms of the Kinetic-Molecular Theory, explain why an increase in temperature at constant volume leads to an increase in pressure. [3]

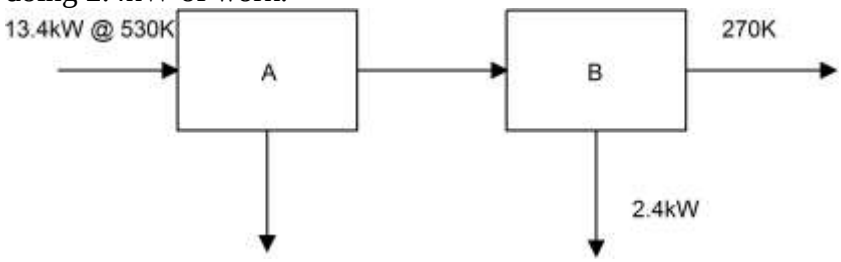
4) Give the lower bound for the change in entropy of a process which occurs at constant temperature. This lower bound is achieved when the process is ____? [4]

5) The reaction: $C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)}$ has $\Delta H° = -2044 kJ\ mol^{-1}$. Determine the standard heat of formation of carbon dioxide. What law (which you used here) asserts that the enthalpies of reactions may be added together? [4]

6) A .3kg iron ingot at 223°C and a .5kg aluminum bar at 345°C are dropped in 1.2L of water at 4°C. What is the final temperature of the system? What is the change in entropy of the total process? Which materials gain entropy, and which lose entropy? [7]

7) A 2m long aluminum rod is placed on a table, and a 1m invar rod is placed parallel to it, with one of its ends touching the aluminum rod. In this way, the system could be viewed as one long rod, which is aluminum for 2/3 of its length, and invar for 1/3. The system is currently at 25°C. If the temperature is increased at a rate of $.35°C\ s^{-1}$, then express the total rod's length as a function of time. Give all coefficients in the function to 6 significant figures. [5]

8) Two Carnot engines function in tandem, such that one rejects heat at a certain temperature, which the other absorbs at the same temperature. Let the first engine be A, and the second B. A intakes 13.4 kW of heat at 530K, and B rejects heat at 270K while doing 2.4kW of work.



a) What was the full name of the man who imagine the first Carnot Engine? [1]

b) What thermodynamic theory did he use to calculate its efficiency? [1]

c) Describe a Carnot engine, in terms of thermodynamic processes. [3]

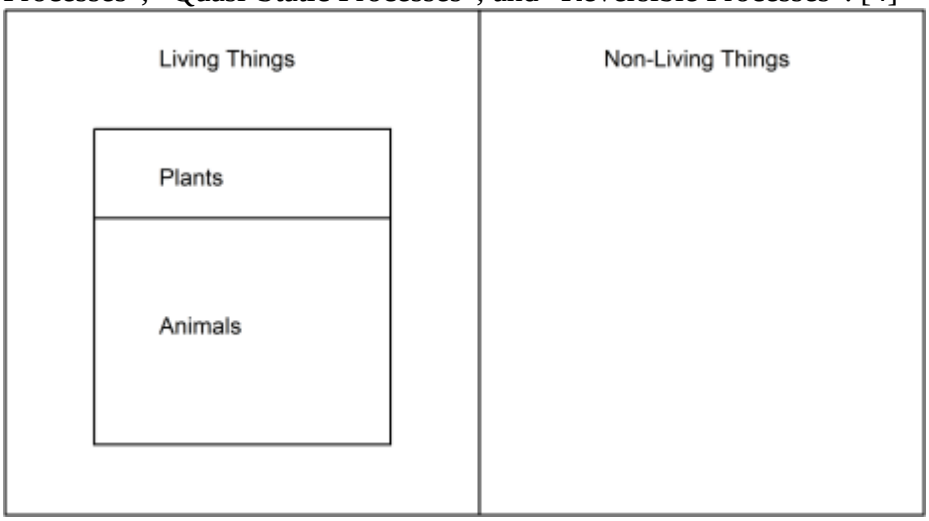
d) What does Carnot's Theorem say about the efficiency of a Carnot engine operating between two absolute temperatures? [1]

e) What does Carnot's Theorem say about the efficiency of a reversible engine which is not a Carnot engine operating between two absolute temperatures? [1]

f) What does Carnot's Theorem say about the efficiency of an irreversible engine operating between two absolute temperatures? [2]

g) Determine the power output (work) of engine A. Show all work, including any laws or theorems you invoke. Elegant solutions will be given additional points. [8+]

9) Draw a diagram similar to the one given which describes the relationship between “All Processes”, “Quasi-Static Processes”, and “Reversible Processes”. [4]



10) A region at 60°C is separated from a region at 25°C by a .01m wrought iron wall. What is the rate of heat transfer between the regions? No suppose that the wall is changed to a three layer wall. The first, with a width of .005m is wrought iron, the second, with a width of .004m is air, and the third, with a width of .005m is wrought iron. What is the rate of heat transfer now (per area)? What properties / constants in this problem (implicitly or explicitly given) are additive. Identify 3 properties or constants (used in the problem) as either intensive or extensive. [8]