Homework #1 — PHYS 603 — Spring 2007
Deadline: **Thursday, March 15, 2007, in class**

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Textbook: Gregory H. Wannier, *Statistical Physics*
Dover 1987 reprint of the 1966 edition, ISBN 0-486-65401-X

Do not forget to write your name and the homework number!

Each problem is worth 6 points.

Ch. 1 The First Law of Thermodynamics

1. **Problem 1.5, Refrigiration by isothermal demagnetization.**

   Derive an analytical formula for the answer; do not plug the numbers (unless you wish to compare with the answer in the textbook).

   Use the First Law and the Curie Law in the form:

   $$dU = dQ + H\,dM, \qquad M = \frac{C}{T}H, \tag{1}$$

   where C is the Curie constant (not heat capacity!), and $U(T)$ depends only on temperature T.

2. **Problem 1.6, A formula for C_p/C_v.**

   Derive this equation for an ideal gas with the equation of state (1.09) $PV = RT$. The textbook sometimes call it a "perfect gas" or a "perfect fluid".

3. **Problem 1.8, Thermal expansion of steel.**

   Use Eq. (1.14). Derive an analytical formula and then plug the numbers.

4. **Problem 1.9, Identities between partial derivatives.**

5. **Problem 1.11, Non-ideal gas $P(V-b) = RT$.**

   Use Eq. (1.13b).

6. **Problem 1.12, Transformation along a straight line in P-V.**

   Derive an analytical formula and then plug the numbers. Use equations $PV = RT$ and $\Delta U = C_V\,\Delta T$. To get C_V, use equations $C_P/C_V = \gamma$ and $C_P - C_V = R$.

7. **Problem 1.13, Adiabatic compression.**

   Derive an analytical formula and then plug the numbers. Use equations $PV = RT$ and $PV^\gamma = \text{const}$ (1.40).

8. **Problem 1.17, Specific heat of steam.**

   Assume that specific heat of steam has the form $C_P = A + BT$ with some constants A and B. Derive an analytical formula for the answer to question (a); do not plug the numbers. Don't do part (b), because the textbook does not explain what is a perfect polyatomic gas.

9. **Problem 1.20, Equation of state from α and B.**

   Plug the expressions for α and B into Eq. (1.13b) and try to integrate the differential dP in terms of dV and dT. The question (a) means that the cross-derivatives must be equal.

10. **Problem 1.21, γ for a mixture of two gases.**

    Use equations (1.35) and (1.39), $C_P - C_V = R$ and $C_P/C_V = \gamma$, and $\Delta U = C_V\,\Delta T$.

Ch. 6 Older Ways to the Second Law

11. **Problem 6.1, Carnot cycle.**

    Derive an analytical formula and then plug the numbers. Use equations $PV = RT$ and $PV^\gamma = \text{const}$ (1.40).

12. **Problem 6.2, Heat pump.**

    Derive an analytical formula and then plug the numbers. The numerical value for the increased efficiency is quite amazing.

13. **Problem 6.6, Heating one body using two other bodies.**

    Describe how the process would be operated and derive analytical equations relating the three initial temperatures to the final temperatures. As far as I can see, getting the final answer requires solving a cubic equations. Solve it, if you know how. If you don't know, check that the numerical answer given in the textbook satisfies your equations. Find also the final temperature of the lower-temperature body in this problem.

14. **Problem 6.8, Otto cycle.**