University of California at Berkeley
Department of Physics
Physics 7B, Spring 1998

First Midterm Exam
February 17, 1998

You will be given 70 minutes to work this exam. You may use a single, handwritten sheet of notes. No printed matter or calculators capable of storing or displaying text are permitted. Your description of the physics involved in a problem is worth significantly more than any numerical answer, so its recommended that you plug in numbers only at the end. Show all work, and take particular care to explain what you are doing. Write your answers directly on the exam, and if you have to use the back of a sheet make sure to put a note on the front. Do not use a blue book or scratch paper.

The first three problem are worth a total of 64 points, divided as shown. The remaining multiple choice questions are worth 3 points each. If you think there is more than or less than one correct answer to a multiple choice question, mark it that way and explain your reasoning briefly.

NAME: ______________________________

SID NUMBER: ______________________________

DISCUSSION SECTION NUMBER: ______________

DISCUSSION SECTION DATE/TIME: ______________

Read the problems carefully.

Try to do all the problems.

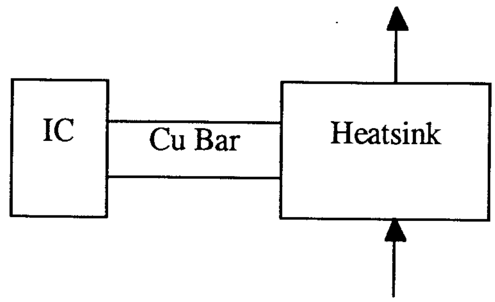
If you get stuck, go on to the next problem.

Don't give up! Try to remain relaxed and work steadily.

Thermal conductivity for liquid water is 0.5 W/m K
Thermal conductivity for copper is 400 W/m K
Specific heat capacity of liquid water is 0.4 Joules/gm/ºK
Specific heat capacity of copper is 4.2 Joules/gm/ºK

R = 8.3 J/mol K   ln 2 = 0.69   ln 3 = 1.1   ln 5 = 1.6

1) (22 points) An IC chip dissipates 2 watts of power, and has to be kept at 35º C while running. Its connected to a heatsink by a short copper bar. The copper bar is 5 mm long, and has a square cross-section, 1mm on a side. The heatsink is cooled by flowing water.



See cover page for constants

a) What temperature must the heatsink be for this to be a steady-state system? (Call this temperature Tc, and find it algebraically before calculating a value)

1 - b) Water flows into the heatsink at 3º C and is heated to 7ºC as it passes through the heatsink. This absorbs the 2 watts of power coming from the chip. How many grams of water need to be pumped through the heatsink per second?

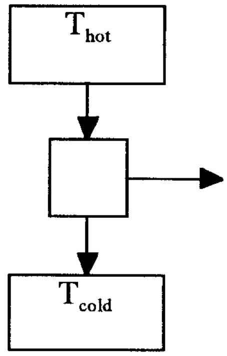
c) You've just finished building this cooling system. Unfortunately, the chip designers have made a mistake, and the chip actually dissipates 4 watts. They suggest you just double the water flow. Would that work? (Note: this is a thermo question, not a question about fluid flow) Explain your reasoning, please.

2) (22 pts) HRK 24-45

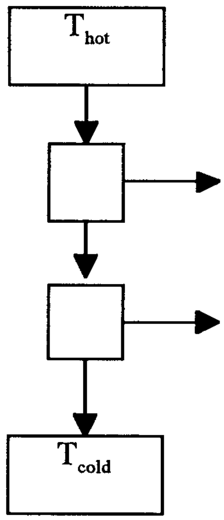
In a motorcycle engine, after combustion occurs in the top of the cylinder, the piston is forced down as the mixture of gaseous products undergoes an adiabatic expansion. Find the average power involved in this expansion when the engine is running at 4000 RPM, assuming that the gauge pressure immediately after combustion is 15.0 atm, the initial volume is 50 cm^3, and the volume of the mixture at the bottom of the stroke is 250 cm^3. Assume that the gases are diatomic and that the time involved in the expansion is one-half that of the total cycle. (Note: demonstrating your understanding of what's happening is a lot more important than getting the exact value)

3) (20 pts) You have a two thermal reservoirs, a hot one at T_{hot} and a cold one at T_{cold}. You need to build an efficient engine to generate a certain amount of mechanical power.

a) You could use a Carnot engine, as shown at the right. What is the efficiency of this setup?



b) Unfortunately, the only Carnot engines you can buy cannot produce enough ouput mechanical power. So you buy two and arrange them so the output heat from one is the input heat to the next, as at right. What is the efficiency of this arrangement? (Be sure to make the definition of your variables clear; without that, it will be very difficult to give partial credit) Consider the sum of works done by the two machines as the output.



3 - c) Draw a PV diagram for the arrangement of part (a). On a separate PV diagram, sketch sample cycles for the gas in each of the two engines in part (b), assuming that the work done per cycle is the same as in part (a). Make sure to label end points, processes, etc.

4) According to the kinetic theory of gases, the pressure of a gas is due to:
a. average kinetic energy of the molecules
b. change of kinetic energy of the molecules as they strike the wall
c. force of repulsion between the molecules
d. change of momentum of molecules as they strike the wall
e. rms speed of the molecules

5) The pressure of an ideal gas of diatomic molecules is doubled by halving the volume. The ratio of the new internal energy to the old is:
a. 1/4
b. 1/2
c. 1
d. 2
e. 4

6) For constant volume processes the specific heat of gas A is greater than the specific heat of gas B. We conclude that when they absorb the same heat at constant volume:
a. A does more positive work than B
b. the temperature of A increases less than the temperature of B
c. the temperature of A increases more than the temperature of B
d. the internal energy of A increases less than the internal energy of B
e. the internal energy of A increases more than the internal energy of B

7) According to the first law of thermodynamics, applied to a gas, the increase in the internal energy during any process
a. is independent of the heat input
b. equals the heat input minus the work done on the gas
c. equals the heat input plus the work done on the gas
d. equals the work done on the gas minus the heat input
e. is independent of the work done on the gas

8) When an ideal gas undergoes a quasi-static isothermal expansion
a. the increase in the internal energy is the same as the heat absorbed
b. the increase in the internal energy is the same as the work done by the gas
c. the increase in the internal energy is the same as the work done by the environment
d. the work done by the gas is the same as the heat absorbed
e. the work done by the environment is the same as the heat absorbed

9) On a very cold day, a child puts his tongue against a fence post. Its much more likely that his tongue will freeze to a steel post than to a wooden post. This is because:
a. steel is a highly magnetic material
b. steel is a better heat conductor
c. steel has a higher specific gravity
d. steel is a better radiator of heat
e. steel has a higher specific heat

10) Units of thermal conductivity are
a. cal cm / (sec C)
b. cal / (cm sec C)
c. cal sec / (cm C)
d. cm sec C / cal
e. C / (cal cm s)

11) The change in entropy is zero for:
a. reversible isobaric processes
b. reversible processes during which no work is done
c. reversible isothermal processes
d. reversible adiabatic processes
e. all adiabatic processes

12) An ideal gas expands into a vacuum in a rigid vessel. As a result there is
a. a change in phase
b. a decrease in the internal energy
c. a change in the temperature
d. an increase in pressure
e. a change in entropy

13) In a reversible process the system
a. is close to equilibrium states throughout, except at the beginning and end
b. is close to equilibrium states only at the beginning and end
c. might never be close to any equilibrium state
d. is always close to equilibrium states
e. is none of the above

14) A heat engine that in each cycle does positive work and rejects heat, with no heat input, would violate
a. Newton's second law
b. the zeroth law of thermodynamics
c. the first law of thermodynamics
d. the second law of thermodynamics
e. the third law of thermodynamics

15) A reversible heat engine and an irreversible heat engine both operate between the same high temperature and low temperature reservoirs. They absorb the same heat from the high temperature reservoir. The irreversible engine:
a. does more work
b. rejects more heat to the low temperature reservoir
c. has the greater efficiency
d. has the same efficiency as the reversible engine
e. cannot absorb the same heat from the high temperature reservoir without violating hte second law