Phys 404
Spring 2010
Homework 1, CHAPTERS "0" and 1
Due Thursday, February 4, 2010 @ 12:30 PM

Read Chapter 1 of Kittel and Kroemer.

Read the chapters in your introductory physics text on heat and thermodynamics, and answer the following questions. You will find these problems to be easier if you complete problem 2 before solving problems 3 through 8. *Clearly print your name on the first page of the homework, and staple the pages together.*

1. a) Briefly describe the absolute temperature scale.
b) State the first law of thermodynamics, defining any symbols you use in an equation.

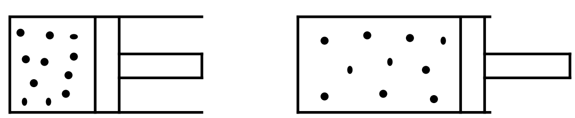
2. Find approximate numerical values (in SI units) for the following quantities in the literature.
a) The specific heat of water for temperatures not too far above freezing.
b) The specific heat of ice for temperatures not too far below freezing.
c) The latent heat of melting of ice.
d) The specific heat of iron near room temperature.
e) The thermal conductivity of window glass.

3. a) Define heat capacity and specific heat. What are the SI dimensions of these quantities?
b) How would you measure the heat capacity of water, using a thermos bottle, a thermometer, a waterproof 100 ohm resistor, a battery, a timer, and electrical meters?

4. a) A 1000 kg car is moving at 30 m/s. The brakes on the car are applied, bringing the car to a full stop. Assuming that there are four brake assemblies made of iron, each of mass 5 kg, and that none of the heat escapes during braking, how much does their temperature rise?
b) Is your answer likely to be an overestimate or an underestimate? Why?

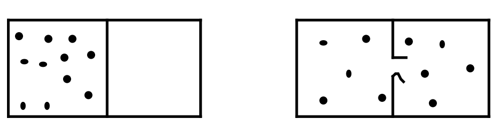
5. A thermos bottle contains a liter of water at +5˚C. 100 gm of ice which have a temperature of -20˚C are dropped into the water. Carefully and quantitatively describe the final state of this system. Assume that the thermos bottle is ideal, so that no heat leaves or escapes. In addition, assume that the heat capacity of water is a constant (it does not depend on temperature), and that the heat capacity of ice is also constant (but not the same constant as water).

6. One mole of an ideal gas is contained in a piston which is held at constant temperature of T=20˚C. The gas slowly pushes the piston so that the volume of the gas expands from 10 cm^3 to 20 cm^3.



a) How much work does the gas do on the piston?
b) How much heat must flow into the gas during this process to maintain the gas at a constant temperature?

In a second experiment at constant temperature, a 20 cm^3 container is constructed with an interior wall in the middle. One mole of gas is initially confined to the left half by the wall, until a hole is punched in the interior. The container is held at a constant T=20˚C.



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c) How much work does the gas do while expanding through the hole?

d) How much heat flows into the gas?

7. a) A room in an old house has 2 square meters of windows which have single layers of glass which are 0.5 cm thick. If the inside temperature is 20˚C, and the outside temperature is 0˚C, how much heat (in joules/sec) does the room loose?

b) Clearly stating your assumptions, estimate how much it costs per day to heat this room under these conditions if the house has electric heat.

8. Calculate the root-mean square velocity of a helium atom in the atmosphere at 0˚C.

9. A fair coin is tossed 10 times, and the total number of heads and tails is counted.

a) What is the probability that precisely 5 heads and 5 tails will be the outcome?

b) What is the probability that precisely 6 heads and 4 tails will be the outcome?

c) The width of the probability distribution can be characterized by the root-mean squared deviation δN_{rms},

$$\delta N_{rms} \equiv \left\langle \left(\frac{1}{2} N - N_h \right)^2 \right\rangle^{1/2}$$

where N_h is the number of heads and N is the total number of tosses. Find δN_{rms} and $\delta N_{rms}/N$ for this problem.

10. A fair coin is tossed 10,000 times, and the total number of heads and tails is counted.

a) What is the probability that precisely 5000 heads and 5000 tails will be the outcome?

b) What is the probability that precisely 6000 heads and 4000 tails will be the outcome?

c) Find δN_{rms} and $\delta N_{rms}/N$ for this problem.