Physics 103b

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Order of Magnitude Physics

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Problem Set 4

Due at *beginning* of class *4 February 1997*

Homework Problems:

1. A flat bottomed bowl of radius R is filled with water to depth H.
   a) Provide an approximate expression for the period, P, of the sloshing mode.
   b) Estimate the damping timescale, T_ν, in the small amplitude limit.
   c) Evaluate P and T_ν for $R = 10\,\mathrm{cm}$ and $H = 5\,\mathrm{cm}$.

2. Shabu shabu, which translates as "swish swish", is a method of Japanese cooking in which thin pieces meat are moved through near boiling water. How does the heat flux into the meat vary with the speed at which it is moved?

3. At what distance would an ice cube in circular orbit around the sun just sublimate in the age of the solar system? The vapor pressure of water over ice is

$$\log_{10}\left(\frac{P}{\mathrm{dyne\,cm^{-2}}}\right) \approx 13.5 - \frac{2.67\times 10^3}{T},$$

   where T is expressed in degrees Kelvin.

4. The future of water on earth. Care and thought, particularly in parts (d) and (e), will be rewarded.
   a) Estimate the total mass of water in the atmosphere at any given time.
   b) Estimate the total mass of water in the oceans.
   c) How many years' worth of the solar energy flux on earth would be required to completely evaporate the oceans? Why don't they evaporate?
   d) To what temperature would the surface of the earth have rise so that there was no longer liquid water on the surface of the earth? The phase diagram on the next page may be useful.
   e) By how much must the luminosity of the sun increase in order to reach the state you found in (d)? Five billion years hence, the luminosity of the sun will begin to increase, eventually becoming 10^3 times more luminous than it is now.

5. How much warmer is a big city [say 10^7 people in a square 20km on a side] than the surrounding countryside? (Hint: the average American uses 10kWatt). Treat two cases:
   a) The city is trapped under a breezeless inversion layer, so all heat must be radiated.
   b) The heat is convected up into the atmosphere and carried away by horizontal winds.

6. Invent a problem of your own.

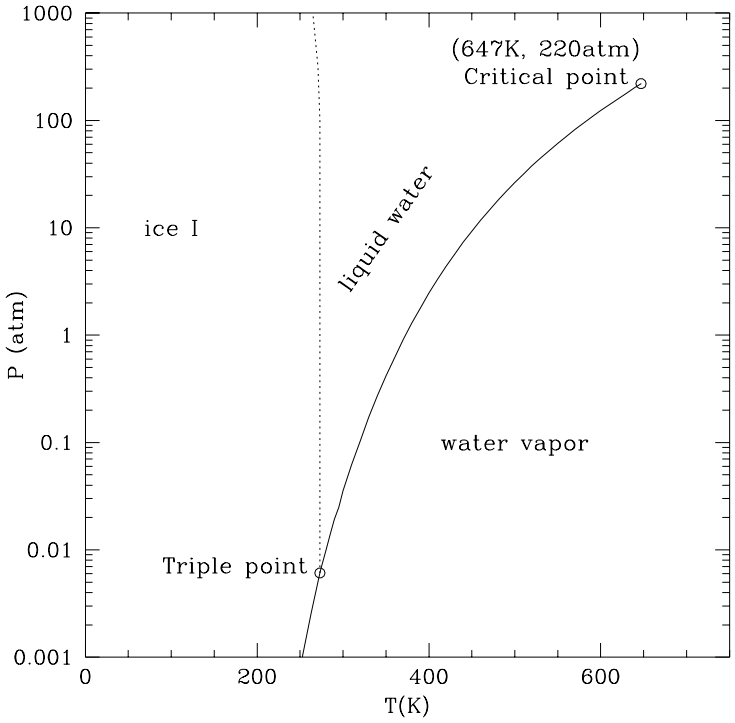

Figure [4b]: Phase diagram of H_2O. $1\,\mathrm{atm} \simeq 10^6\,\mathrm{dyne\ cm^{-2}} = 10^5\,\mathrm{pascal}$.