PHYSICS-2
Elementary Physics of Energy

Supplement Re Specific Heat and Latent Heat
Date: APRIL 17, 2011 in class

As discussed in class materials can be heated or cooled either in a single state or through different states. Here are a few salient points regarding these processes. This should be regarded as a "theory supplement" to the problems in HW3.

- **States or phases of matter** We discussed the solid, liquid and vapour (gas) state of matter. All materials show these different phases or states of matter. Some materials show several sub-types of state as well, for example the familiar Ice phase has several different types of crystal structures under pressure. We will not worry about these finer details, we will simply think of these as three distinct states of matter.

- **Changes within a state or phase** Here we are interested in heating up or cooling matter while remaining within a phase. For instance we could put a cup of water in the microwave and heat it, to make our favorite hot drink, this is an example of heating of water remaining in the water phase. Similarly hot water left in the cup cools in time, remaining as water.

  In these two processes, heating or cooling, we are either supplying heat energy to the body or extracting from it. In the case of cooling of a cup of water, it is loosing its heat energy by radiation to the surrounding and also to contact with the air around it.

  The specific heat is now introduced via the formula

  $$\Delta Q = c \times M \times \Delta T,$$

  where ΔQ is the heat added to or extracted from the body, M the mass of the body, ΔT the change in temperature and c the specific heat of the body. One standard set of units measures ΔQ in calories, M in grams, ΔT in degrees celsius, then c is measured in calories/(gm degree C). Thus

  $$[c] = \frac{calorie}{gm \times C^0},$$

  and to see the other variations, we can use $1cal = 4.2J$ to convert to Joule units, as well as use kilograms and kilor calories instead.

- **Change of state at a fixed temperature** Since under heating solids melt, liquids boil, and also with cooling since liquids freeze and vapors condense, we find that these processes require or involve and extra heat energy. The origin of this extra heat was discussed in class as being related to the nature of the states. Solids are very regular so have a low energy, liquids are less regular atoms move around and so the potential energy is higher and for gases even higher.

  We define the latent heat as the heat energy per unit mass added or taken away in a given change of phase (or state) at constant temperature.

  $$\Delta Q = M \times L.$$

  Example: At the melting temperature the solid and the liquid coexist and can be transformed into each other by adding or removing heat at $T - T_{melting}$. Similarly for boiling of water, the vapor and liquid phases coexist at the boiling point, and we can change the phase with the extra latent heat.

  Dimenionally

  $$[L] = \frac{calorie}{gm}.$$

  Typical values of the latent heat and specific heat are given in the class notes of April 12th and 14th.