February 23: Heat and Phase Changes

Objectives

- Define and differentiate heat and temperature.
- Explain the role of heat in conservation of energy.
- Describe the energy transfer of phase changes.

What's the point?

- What is temperature?
- How is heat related to energy?

Heat

Internal energy is the energy of molecules in a sample beyond the energy of motion and position of the sample itself. It is the kinetic energy of random molecular motion plus the potential energies between atoms. **Heat** is internal energy transferred between two objects at different temperatures. Since heat is energy, the SI unit of heat is the SI unit of energy: the joule (J). Heat can also be measured in calories: a **calorie** (cal) is the energy needed to raise the temperature of one gram of water 1 °C. 1 cal = 4.184 J. The **food calorie** used in the USA is actually the kcal = 1,000 cal.

Heat and Conservation of Energy

When an object or system of objects appears to lose potential or kinetic energy, usually all that is happening is the "lost" energy is converted to internal energy: kinetic and potential energy, but of objects too small to see.

Temperature

Kelvin **temperature** (which is Celsius temperature + 273.15) is a measure of the *average* molecular kinetic energy. Specifically, the average translational kinetic energy of a molecule in a substance at temperature T is $1/2\ k_B T$, where the "Boltzmann constant" $k_B = 1.38066 \times 10^{-23}$ J/K.

Heat Capacity

The **heat capacity** C of an object is the amount of energy needed to raise the object's temperature 1 °C. The units of heat capacity are J/K. Heat capacity is closely related to **specific heat**, the amount of energy needed to raise the temperature of one kilogram of a substance by 1 °C. The units of specific heat are J/(kg K).

Phase changes

Molecules gain kinetic energy going from gas to liquid or from liquid to solid, and lose kinetic energy going the other way. This is because of the lower potential energy of molecules in solids than liquids than gases.

Phase changes often proceed at constant temperatures, as transferred energy changes the molecules' potential but not kinetic energies.