Energy, Entropy, and Everything
spring 2001

Study Guide for First Test

Basic concepts. You should be able to define and explain each of the following concepts in your own words:

- energy (kinetic, gravitational, elastic, thermal, chemical, electrical, nuclear)
- power; work; heat; temperature
- combustion; hydrocarbon; carbohydrate
- voltage; electric current; electric resistance
- proton; neutron; isotope; half-life; α and β decay; fission; fusion

Formulas. You should be able to use the following formulas to solve problems similar to those on the quizzes:

- K.E. = $\frac{1}{2}$(mass)(speed)^2 = $\frac{1}{2}mv^2$
- G.E. = (mass)(local gravitational constant)(height) = mgh
- Δ(T.E.) = (mass)(specific heat capacity)(temperature change) = $mC\,\Delta T$
- E.E. = (voltage)(current)(time) = $VI\,\Delta t$
- power = energy/time or energy = (power)(time)
- (rest energy) = (mass)(speed of light)^2 = mc^2

Most of these formulas work only with official "SI" units: meters, seconds, kilograms, joules, volts, amperes. In these units, the local gravitational constant near earth's surface is approximately 9.8 J/kg·m, the specific heat capacity of water is 4200 J/kg·°C, and the speed of light is 3×10^8 m/s.

Units and conversions. You should know the following definitions and approximate unit conversion factors and how to use them. (Some of these are rounded values—if you can remember more digits, that's fine, but unnecessary.)

- 1 watt = 1 joule/second
- 1 kilowatt-hour = 3600 kilowatt-seconds = 3.6 million watt-seconds = 3.6 million joules
- 1 kilocalorie = 4200 joules = energy to raise temp. of 1 kg of water by 1°C
- 1 BTU = 1000 J = energy to raise temp. of 1 pound of water by 1°F

Other useful facts. You should also know the following:

- Melting a kilogram of ice requires 80 kilocalories.
- Boiling a kilogram of water (one liter) requires 540 kilocalories
- Energy available from foods, per gram: carbohydrates and proteins, 4 kcal; fats, 9 kcal.
- 1 jelly donut = 250 kcal = 1 megajoule.
- Combustion of gasoline releases 31,000 kcal per gallon, or 44 million joules per kilogram. Other common chemical fuels have similar values on a per-kilogram basis.
- A typical person (or lightbulb) converts energy at a rate of 2000 kcal/day, or 100 watts.
- A typical large power plant produces electrical energy at a rate of 10^9 watts.
- Nuclear reactions typically release 10^6 times more energy per atom than chemical reactions.
- Electricity costs about 7 cents/kwh; natural gas, \$6/MBTU; gasoline, \$1.50/gallon.