CHAPTER 18
Thermodynamics

Thermodynamics comes from Greek words meaning "movement of heat".

Study of how heat is transformed into mechanical energy.

Questions

- Can you cool off your apartment by leaving the door of the refrigerator open?
- Can you warm up your apartment by turning on the oven and leaving it open?
- How does an air conditioner cool your house?

Internal Energy

The energy contained in a system. This includes

- Energy of motion (atoms or molecules vibrating and moving)
- Energy in chemical bonds
- Energy in nuclear bonds
- Energy in mass ($E=mc^2$)

First Law of Thermodynamics

- When heat flows to or from a system, the system gains or loses an amount of energy equal to the amount of heat transferred. (conservation of energy)
- Heat added to a system = increase in internal energy + external work done by a system (recall both heat and work are forms of energy)

Adiabatic processes

- When no heat enters or leaves the system.
  - System is insulated from the environment
  - Or happens too fast for heat to enter or leave.
  - Then by first law, no heat added, so external work done must be offset by change in internal energy.

Examples of Adiabatic Process

- Blow air out of your mouth so it expands, and the air feels cool.
- Blow air out of your mouth so it doesn't and it still feels warm.
- Pump air into a bike tire and we do work on the system, so the internal energy (temperature) increases.
- VE 15-3,4,5

Weather and the First law

- Air temperature rises as heat is added or as pressure is increased.
- Example: When the wind blows air down from a tall mountain to lower levels, the pressure is increased and the temperature is raised. This occurs in the chinook winds that occur when wind blows down from the Rocky Mountains across the Great Plains.

Second Law of Thermodynamics

- Heat never flows spontaneously from a colder object into a hotter object.
- Easy to turn work into heat.
- To turn heat into work, it must flow from a hotter object into a cooler object.
- Only some of the heat is converted to work.
- VE 15-6,7,8

Ideal Efficiency

- Ideal efficiency = $(T_{hot}-T_{cold})/T_{hot}$
- All temperatures in Kelvin.
- Example: A steam engine operating between 300 and 500 K would have an efficiency of

  (500-300 K)/500 K=.4 = 40%
- Important note: efficiency is always less than 100%

Efficiency Question

- Which is more efficient, a steam engine operating between 100°C and 200°C or one operating between 100°C and 400°C?

Real Efficiency

- In a real case, such as an automobile engine, the amount of heat converted to useful work (such as the kinetic energy of the car) is reduced even more due to friction.
- In other words, energy tends to move towards less useful forms - order tends to disorder.

Thermodynamics of Hell

A true story. A thermodynamics professor had written a take home exam for his graduate students. It had one question: "Is hell exothermic or endothermic? Support your answer with a proof." Most of the students wrote proofs of their beliefs using Boyle's Law or some variant.

One student, however, wrote the following: First, we postulate that if souls exist, then they must have some mass. If they do, then a mole of souls can also have a mass. So, at what rate are souls moving into hell and at what rate are souls leaving? I think that we can safely assume that once a soul gets to hell, it will not leave. Therefore, no souls are leaving.

As for souls entering hell, lets look at the different religions that exist in the world today. Some of these religions state that if you are not a member of their religion, you will go to hell. Since there are more than one of these religions and people do not belong to more than one religion, we can project that all people and all souls go to hell. With birth and death rates as they are, we can expect the number of souls in hell to increase exponentially.

Now, we look at the rate of change in volume in hell. Boyle's Law states that in order for the temperature and pressure in hell to stay the same, the ratio of the mass of souls and volume needs to stay constant. So, if hell is expanding at a slower rate than the rate at which souls enter hell, then the temperature and pressure in hell will increase until all hell breaks loose. Of course, if hell is expanding at a rate faster than the increase of souls in hell, than the temperature and pressure will drop until hell freezes over. It was not revealed what grade the student got.