

3.012 Practice Problems for Recitation 1 (09.13.05)

Part I. System Classification (open, closed, isolated, adiabatic): state your assumptions!

1. What kind of system is a well-insulated thermos filled with hot tea and ice cubes? What happens to the energy distribution of the material in the thermos over time? What happens to the entropy?

Isolated system, with an energy distribution that flattens out over time (due to change from multi-phase to single-phase system), while entropy increases.

1. What kind of system is a greenhouse? What category of energy is relevant?

Closed, assuming a sealed greenhouse. Specifically, heat is exchanged (not work).

1. What type of system is a balloon filled with helium? How would you describe its walls?

*Open. Gas exchange goes on over time (so the balloon sinks), and it is theoretically possible that the gases may carry heat; this is because the walls are **semi-permeable**.*

1. What type of system is a hollow ball made of a thick but flexible rubber?

*If we can imagine the object above, it is an **adiabatic** system. Mechanical work may be performed by pressing on the ball, but heat cannot travel through the insulating rubber. Also note that this system is closed to matter.*

1. What type of system is the earth?

*The earth is approximately a **closed** system, assuming transfer of matter with the universe is fairly negligible, whereas the energy term is certainly large.*

Part II. Thermodynamic Processes.

1. Explain the differences between a reversible and irreversible gas expansion. Imagine a process for each (real or idealized). Compare (qualitatively) the rates of change for the thermodynamic variables in the two processes.

The two imagined processes would start from the same basic components: a cylinder of gas and a piston. For the reversible process, the piston would move very slowly and be frictionless, while for the irreversible process the piston would move quickly and experience friction. Differences between the processes are summarized below:

Reversible	Irreversible
Exactly reverse process is possible.	One-way process only.
System at (or infinitesimally near) equilibrium at all times (t).	System may be far from equilibrium, but will reach equilibrium at long t (final state).
TD variables (P, V) change slowly. (Infinitesimally-slowly moving piston.)	TD variables may change quickly, even as immediate step-changes.
No dissipative processes (e.g., friction).	Energy 'loss' to surroundings is typical.
No permanent change in surroundings or system – may return to initial state.	Causes permanent change in universe – including entropy increase.

Note: many of these differences are inter-related.

2. Give an example of a natural process that happens spontaneously. Is it obvious how entropy increases in this system? What dissipative process may be at play?

Consider the bouncing ball discussed in class and in the supplementary reading. Thermal energy is dissipated through friction and sound waves, and increases the entropy of the universe by this random thermal motion.