T3 Gas Processes

Chapter Overview

Introduction

In chapter T2, we developed a simple newtonian model for an ideal gas. In this chapter we will use the model to explore thermal *processes* in which the properties of a gas change with time. This chapter provides essential background for the rest of the unit, especially for chapters T8 and T9.

Section T3.1: Review of Heat and Work

The technical terms **heat** and **work** both describe energy flowing across a system boundary during a process. The *heat* Q is that part of the energy flow driven by a temperature difference between the system and its surroundings; the *work* W refers to any other energy flow across the boundary (note that this is *not* the same as the "k-work" [dk]defined in unit C). The energy stored *inside* a system boundary is the system's **thermal energy** U. These quantities are linked by the **first law of thermodynamics:**

$$\Delta U = Q + W \qquad \text{(T3.1)}$$

Purpose: This equation expresses the law of conservation of energy in the context of thermodynamic systems.

Symbols: ΔU is the change in a system's thermal energy in a given process; Q and W are the heat and work, respectively, that have flowed into or out of the system during that process.

Limitations: There are none. Heat and work are mutually exclusive, but together they include all the ways that energy can flow into or out of a system.

Note: In this text, both Q and W are positive when energy flows *into* the system. Some other texts adopt a different sign convention for W.

Section T3.2: Work During Expansion or Compression

Because a gas molecule will rebound from a moving piston with a different energy than it had originally, changing a gas's volume involves work, which we can calculate as follows:

$$dW = -P\,dV \qquad \text{(T3.6)}$$

Purpose: This equation expresses the thermodynamic work dW done on a gas during an infinitesimal volume change dV.

Symbols: P is the gas pressure during the volume change.

Limitations: The volume change must be small enough that P does not change significantly during the process, and slow enough that the forces on the piston are essentially in balance, the piston's kinetic energy is negligible, and the gas is in equilibrium with itself.

Note: To find the work W involved during a process in which the pressure varies, one must integrate this expression; see section T3.5.