8.1: Background Material

Text References

- isochoric process
- gamma gas constant
- adiabatic process

A Cyclic Process

In this lab we will be using a cyclic process and a measurement of only pressure to compute the constant γ for the confined gas (which is just air). The process goes like this:

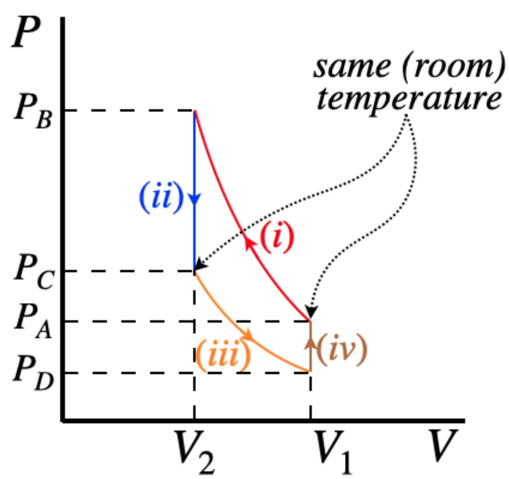
i. Air that is confined to a plastic soda bottle at room temperature is very suddenly compressed to a smaller volume with a boom arm.
ii. The air, which is now hotter from the sudden compression, is held at the same volume (the boom arm is held in place) while it slowly returns to room temperature.
iii. The boom arm is now removed, very suddenly returning the air to its original volume.
iv. The air, cooler from the sudden expansion, is kept at the same volume while it slowly returns to room temperature.

Throughout this cyclic process, we monitor the pressure. It should be clear that the pressure changes 4 times during this process – it increases when the air is compressed (i), decreases as it cools at constant volume (ii), decreases as it expands (iii), and increases as it warms (iv). Considering how many times the gas changes temperature and volume, one might think that one or both of these quantities are needed to compute the value of γ, but surprisingly this is not the case.

The secret to deriving γ purely from the pressure measurements lies in the *types of processes* involved in the cycle. From the text reference regarding adiabatic processes, we saw in Example 2 that sudden compressions (and expansions) can be modeled with adiabatic processes. This accounts for two of the processes, and the other two occur at constant volume. Equations of state that apply to these processes link their endpoints to each other, and we also know something about the endpoints. In particular, the temperature before process (i) is the same as after process (ii) and after process (iv) (indeed the entire thermodynamic state is the same before (i) as after (iv), as the cycle is complete).

A major part of this lab is figuring out the "physics problem" that outlines the process for computing γ, so we won't do that here, but it is helpful to look at the cycle in a PV diagram, labeling every part of it that we can:

Figure 7.1.1 – PV Diagram of Cycle



The only quantities that matter are at the endpoints of these processes. Our measurements will give the four pressure values. The volumes and temperatures are unknown, but the endpoints are related to each other. Two of the endpoints have the same temperature, the endpoints of process (ii) have the same volume (as do the endpoints of process (iv)), and the endpoints of process (i) are related by the adiabatic equation of state, as are the endpoints of process (iii)). Along with this, the air also satisfies the ideal gas law. Combining all of these together will lead to a solution for γ in terms of three of the four measured pressures. You will need to work this out before inserting the data to get an answer. [*Hint: You will find that this goes much easier if you express everything in terms of* P *and* T, *rather than* P *and* V.]

This page titled 8.1: Background Material is shared under a CC BY-SA 4.0 license and was authored, remixed, and/or curated by Tom Weideman directly on the LibreTexts platform.