15.5 Adiabatic Process

- **Ex. 1** How much work does an Ideal Gas of 3 moles at 373 K do when expanding isothermally (at constant temperature) to 4 times its original volume?

**Adiabatic Expansion or Compression – No heat flow, \( Q = 0 \)**

- **Intro.**
- **Ex. 2.** Imagine a monatomic Ideal Gas that expands quickly (relatively adiabatically) and in the process drops its temperature from \( T = 405 \text{ K} \) to \( 245 \text{ K} \). What would be the ratio of final and initial volumes if its slow compression (relatively isothermal) did the same amount of work?

- **P – V relation for Adiabatic Compression/Expansion**
  - Air compressor

15.7 The Second Law of Thermodynamics

**Conceptual Question 1** Say a device takes 10,000 J of internal energy from a hotter reservoir and takes 5,000 J of internal energy from a colder reservoir.
- (a) Does this violate the 1st law of thermodynamics?
- (b) Does it violate the 2nd Law of thermodynamics?

15.8 Heat Engines

- **Engine Examples**
  - **Turbine**
    - **Demo**
    - **Ex. 3** Let’s say that a factory wants to increase their energy efficiency by harnessing some of that energy literally lost up the chimney. So they put a series of turbines up the smoke stack. Say the air enters the chimney at about \( 100 \circ \text{C} (373 \text{ K}) \), and leaves at \( 34 \circ \text{C} (297 \text{ K}) \). Per liter of air, i.e., roughly \( 1.29 \times 10^{-3} \text{ kg} \) or \( (0.00129 \text{ kg} / 0.028 \text{ kg}) = 0.046 \text{ moles} \); at the most, how much mechanical work is done?
  - **Demo: Sterling Engine**

15.9 Carnot’s Principle and the Carnot Engine

- **Demo**
- **Efficiency**
  - **Conceptual Question 2** Improving the efficiency of a carnot engine. How would the following changes to the system / reservoirs change the efficiency of the engine?

- **Ex. 4** A Carnot engine has an efficiency of 0.700, and the temperature of its cold reservoir is 378 K. (a) Determine the temperature of its hot reservoir. (b) If 5230 J of heat is rejected to the cold reservoir, what amount of heat is put into the engine?
• Ex. 5 Imagine a carnot engine that, on a summer day (303 K) looses 1/5 as much energy up the chimney as it does work. For the same input energy, what would be the ratio of work to heat loss in the winter (286 K)?

Physics 220

HW 32 statement

Ch15 Pr. 19, 76, 46, 52

Problems from Cutnell & Johnson 6th Ed., solutions from accompanying source.

19. Three moles of an ideal gas are compressed from $5.5 \times 10^{-2}$ to $2.5 \times 10^{-2}$ m$^3$. During the compression, $6.1 \times 10^3$ J of work is done on the gas, and heat is removed to keep the temperature of the gas constant at all times. Find (a) $\Delta U$, (b) $Q$, and (c) $T$, the temperature of the gas.

76. The input heat for an engine is $2.41 \times 10^4$ J, and the rejected heat is $5.86 \times 10^3$ J. Find the work done by the engine.

46. Five thousand joules of heat is put into a Carnot engine whose hot and cold reservoirs have temperatures of 500 and 200 K, respectively. How much heat is converted into work?

52. From a hot reservoir at a temperature of $T_1$, Carnot engine A takes an input heat of 5550 J, delivers 1750 J of work, and rejects heat to a cold reservoir that has a temperature of 503 K. This cold reservoir at 503K also serves as the hot reservoir for Carnot engine B, which uses the rejected heat of the first engine as input heat. Engine B also delivers 1750 J of work, while rejecting heat to an even colder reservoir that has a temperature of $T_2$. Find temperatures (a) $T_1$ and (b) $T_2$. 