CHEM 361A - Lecture 5 Activity
Adiabatic Processes and Heat Engines

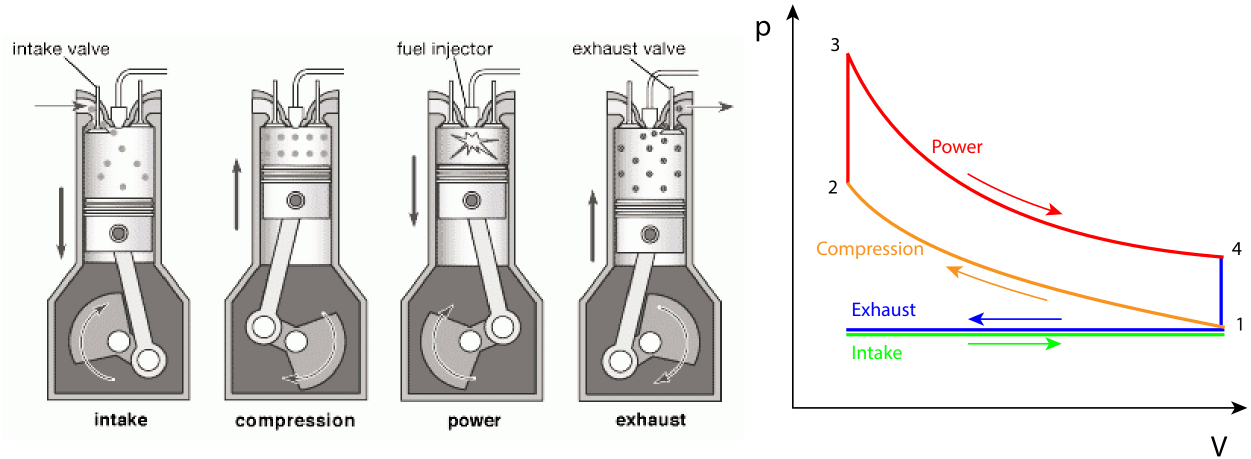
In Class

1. Make the following table and fill in everything:

Table 1: Table of thermodynamic properties.

	Isothermal	Adiabatic	Isobaric	Isochoric
q				
w				
ΔU				
ΔH				

2. The typical gasoline car engine performs a cycle with four parts to generate energy: Intake, Compression, Power, and Exhaust. These four parts are illustrated in Figure 1a. This process can be modeled using the Otto Engine. The Otto Cycle is shown in Figure 1b where the compression and power strokes are assumed to be adiabatic, reversible processes.



(a) The typical four stroke gasoline engine cycle.

(b) The idealised Otto Cycle.

Figure 1: The Four Stroke Engine

Assume that there is 0.2 moles of ideal, diatomic gases and that the conditions at each part of the cycle is found in Table 2.

(a) What is the work performed by this process?

(b) What is the heat inputted to this process?

Table 2: Otto Cycle Conditions

	Point 1	Point 2	Point 3	Point 4
P (kPa)	100	465.6	1000	
V (L)			1.0	3.0
T (K)	180.4		600	

(c) What is the efficiency of the process?

(d) Assuming that the typical passenger car operates with an efficiency of 0.2 to 0.3, what might cause the difference in efficiency compared to the idealised Otto Cycle?

3. For a reversible, adiabatic process we saw that pressure and volume are related by

$$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma} \quad \text{where } \gamma = C_{p,m}/C_{V,m}$$

We will now relate pressure and temperature for a reversible processes. Starting with a reversible adiabatic process, substitute in the Ideal Gas Law for V_1 and V_2 and show that the relationship between pressure and temperature for a reversible, adiabatic process is

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{(\gamma-1)/\gamma}$$

Homework

4. A cloud mass moving across the ocean at an altitude of 2000 m encounters a costal mountain range. As it rises to a height of 3500 m to pass over the mountains, it undergoes a reversible, adiabatic expansion. The atmospheric pressure at 2000 m and 3500 m is 0.802 and 0.602 atm respectively. If the initial temperature of the cloud mass is 288 K, what is the cloud temperature as it passes over the mountains? If you are on the mountain, should you expect rain or snow? Assume that $C_{p,m}$ for air is 28.86 J K^{-1} mol^{-1}. ($T = 265$ K; snow)

5. 0.27 moles of neon (a monatomic gas) initially in a container at 2.50 atm and 298 K and allowed to expand adiabatically.

   (a) For a reversible, adiabatic expansion to 1.0 atm calculate

      i. The final temperature ($T = 207$ K)

      ii. The total work for this process ($w = -306.7$ J)

      iii. ΔH ($\Delta H = -510.5$ J)

(b) The relationship between pressure and temperature for a monatomic gas undergoing an irreversible adiabatic expansion is

$$T_2 = \frac{2}{5}\left(\frac{p_{ex}}{p_1} + \frac{3}{2}\right) T_1$$

where p_{ex} is the pressure the gas is expanding against, and p_1 is the initial pressure of the gas. For an irreversible, adiabatic expansion against 1.0 atm of pressure calculate

i. The final temperature ($T = 226.5$ K)

ii. The total work for this process ($w = -241$ J)

iii. ΔH ($\Delta H = -401.1$ J)

6. The cycle illustrated in Figure 2 is performed with 2 moles of an monatomic ideal gas.

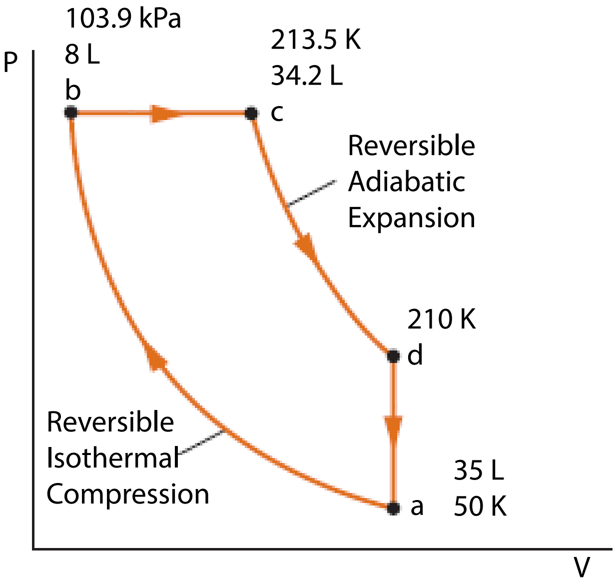


Figure 2: P-V diagram for a complete cycle of a process.

(a) What is the work performed by this process? ($w = -1582$ J)

(b) What is the heat inputted to this process? ($q_{in} = 6800.3$ J)

(c) What is the efficiency of the process? ($\eta = 0.228$)

(d) What is the ΔH of the process from point b to point c? ($\Delta H = 6797$ J)