1. Chapter 20
   - Equipartition Theorem: \( \frac{1}{2}kT \) per d.o.f., per molecule
   - \( E_{\text{th}} = \frac{f}{3}kT \) per molecule
   - \( \langle KE \rangle = \frac{3}{2}kT \) per molecule \( \Rightarrow \frac{1}{2}MV_{\text{rms}}^2 = \frac{3}{2}kT \)
     \[ V_{\text{rms}} = \sqrt{\frac{3kT}{m}} \]

2. Degrees of Freedom: \( f \)
   - \( E_{\text{th}} = nC_vT \)
   - Diagram showing:
     - \( C_v = \frac{3}{2}R \)
     - \( f = 3 \)
     - \( f = 5 \)
     - \( f = 7 \)
Is the following graph of heat capacity vs. temperature that of a monoatomic gas or a diatomic gas?

A) Monoatomic  B) Diatomic  C) Not enough info

Suppose I have 10 J of energy that I want to give to a sample of air via heat. In order to get the largest temperature change, should I give this heat to the gas at 50 K or at 300 K?

A) 50 K  B) 300 K  C) no diff
For a monoatomic gas, what fraction of its total internal energy is translational kinetic?

A) 33.3%  
B) 50.0%  
C) 66.7%  
D) 100%  
E) Depends on the temperature.

An ideal diatomic gas, with molecular rotation but without any vibration, loses a certain amount of energy as heat $Q$. Is the resulting decrease in the internal energy of the gas greater if the loss occurs in a constant-volume process or in a constant-pressure process?

A) Constant-volume process  
B) Constant-pressure process  
C) No difference

ANS: A
Adiabatic, pt. II.

Reminder:

\[ E_{\text{ul}} = n C_v T = \frac{f}{2} n R T = \frac{f}{2} N k T \]

Adiabatic Constant

\[ \gamma = \frac{C_p}{C_v} = \frac{f+\alpha}{f} \]

\[ C_v = \frac{f}{\alpha} R \]

\[ C_p = C_v + R = \frac{f+\alpha}{\alpha} R \]

<table>
<thead>
<tr>
<th>f</th>
<th>( \gamma )</th>
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<tbody>
<tr>
<td>3</td>
<td>( \frac{5}{3} \approx 1.67 )</td>
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<tr>
<td>5</td>
<td>( \frac{7}{5} \approx 1.40 )</td>
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<tr>
<td>7</td>
<td>( \frac{9}{7} \approx 1.29 )</td>
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Adiabatic Processes

\[ dU = nC_v dT \]

\[ -p dV = nC_v dT \]

\[ p = \frac{nRT}{V} \]

\[ \frac{\partial V}{\partial T} = \frac{nR}{p} \]

\[ T_i V_i^{\gamma-1} = T_f V_f^{\gamma-1} \]

\[ P_i V_i^\gamma = P_f V_f^\gamma \]

\[ PV^\gamma = \text{constant} \]

\[ \gamma = \frac{C_p}{C_v} = \frac{C_v + R}{C_v} \]

\[ 1 < \gamma \leq \frac{5}{3} \]

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<th>f</th>
<th>3</th>
<th>5</th>
<th>7</th>
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<tr>
<td>V</td>
<td>( \frac{5}{3} = 1.67 )</td>
<td>1.4</td>
<td>( \frac{9}{7} \approx 1.29 )</td>
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Take gas ($\gamma = 1.4$) and compress quickly to half its initial volume. (adiabatically)

(a) What's $\left( \frac{P_f}{P_0} \right)$?

(b) What's $\left( \frac{T_f}{T_0} \right)$?

(c) Would our answers MC or dec. if we used monatomic gas? (Draw pV diagram)

(a) $P_f V_f^{\gamma} = P_0 V_0^{\gamma}$, with $V_f = \frac{1}{2} V_0$

$P_f = (2)^{\frac{\gamma}{\gamma - 1}} P_0 = (2^{1.4}) P_0 \approx 2.64 P_0$

or...

$P_f = 2.64$

(b) $T_f = T_0 \left( \frac{V_0}{V_f} \right)^{\gamma - 1} = T_0 (2)^{0.4} \approx 1.32 T_0$

$\frac{T_f}{T_0} \approx 1.32$

(This is like 300K -> 400K, so you can heat a gas up quite a bit!)}