Lecture 15: learning objectives

You will be able to define and calculate the work done on or by a gas.

You will be able to state and apply the first law of thermodynamics.

You will be able to identify and define the four most common thermal processes.
Thermodynamic work

Work done on a gas:
The work done on a gas at constant pressure is the (negative of the) product of the pressure and the change in volume.

\[ W = -P \Delta V \]

Note that the change in volume is negative, so this is a positive number.

If the gas expands, then we say that work is done by the gas. Work done by the gas is negative.
First law of thermodynamics

First law:
The change in thermal (internal) energy ($U$) of the system is equal to the heat ($Q$) added to the system plus the work ($W$) done on the system.

$$\Delta U = U_f - U_i = Q + W$$

Q is positive when heat is transferred to the system.

Q is negative when heat is transferred from the system.
Thermal processes

There are four common types of thermal process.

**Isobaric:**
Pressure is constant throughout the process.

**Isovolumetric:**
Volume is constant throughout the process.

**Adiabatic:**
No heat is transferred to or from the system \((Q=0)\) during the process.

**Isothermal:**
Temperature is constant throughout the process.
Thermal processes

There are four common types of thermal process.

**Table 12.2** The First Law and Thermodynamic Processes (Ideal Gases)

<table>
<thead>
<tr>
<th>Process</th>
<th>$\Delta U$</th>
<th>$Q$</th>
<th>$W$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isobaric</td>
<td>$nC_v \Delta T$</td>
<td>$nC_p \Delta T$</td>
<td>$-P \Delta V$</td>
</tr>
<tr>
<td>Adiabatic</td>
<td>$nC_v \Delta T$</td>
<td>0</td>
<td>$\Delta U$</td>
</tr>
<tr>
<td>Isovolumetric</td>
<td>$nC_v \Delta T$</td>
<td>$\Delta U$</td>
<td>0</td>
</tr>
<tr>
<td>Isothermal</td>
<td>0</td>
<td>$-W$</td>
<td>$-nRT \ln \left( \frac{V_f}{V_i} \right)$</td>
</tr>
<tr>
<td>General</td>
<td>$nC_v \Delta T$</td>
<td>$\Delta U - W$</td>
<td>(PV Area)</td>
</tr>
</tbody>
</table>