BID: Thermodynamic Processes

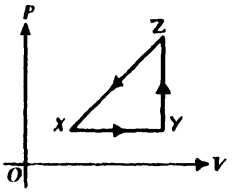
The Big Idea

Work, heat, and internal energy of a system are all connected. ($\Delta U = Q + W$) Work in a system involving gases is governed by the equation: $W = -P\Delta V$.

More details

The important detail here dealing with the First Law of Thermodynamics ($\Delta U = Q + W$) is to keep track of the signs for each component. Since we're talking about the change in energy in a system, it makes sense that **Q** is heat added into the system and **W** is work done on the system.

When talking about work, heat, and energy in a thermodynamic system, the problem will often be looking at a gas in a situation like a piston. In this case, there may be a thermodynamic diagram (like the one shown to the right) showing the "path" of the process and the corresponding changes in pressure and volume of the gas.



When moving from point **y** to point **z**, there is no change in volume (isochoric or isovolumetric), so there is no work done by or on the system ($W = -P\Delta V$). However, for the pressure to increase, heat had to be added to the system. Conversely, if you move from **z** to **y**, heat left the system. Moving from **x** to **y** (isobaric), the gas expanded or "pushed" on its surroundings, thereby doing work on its surroundings. Using $W = -P\Delta V$, with a positive change in volume, will give a negative work answer (meaning work was done BY the system). Moving from **y** to **x**, would mean the gas is compressed or work was done ON the system. The work done over the course of a process is the area underneath the curve. If the process is proceeding toward the right (a larger volume), then the work is done BY the system on its surroundings and has a negative sign. If the process goes to the left, then work is done by the surroundings ON the system and has a positive sign (as it increases the internal energy of the system).

How to recognize it

Problems will either be a plug and chug of the 1st Law (ex: #3 on WS 3) or they will include a pressure/volume work pathway diagram (like above).

How to tackle it

Use the two formulas listed above, and watch for directionality on the diagram for signs.

Pitfalls to watch for

1) Be careful of the signs for each part and the whole.
2) Watch the signs! (direction of process is important)
3) See #1 and #2.

Example problem

*Describe whether Q, W, and ΔU are positive or negative during process **zx** listed in the diagram above. Explain your reasoning.*

Solution:

W>0 Work is done on the system. The gas is compressed. ($W = -P\Delta V$ & $\Delta V<0$)

Q<0 Heat is lost from the system. With a smaller volume, there should be a corresponding increase in pressure at the same temp, and since pressure also dropped, that indicates a lower temp, so heat left the system.

ΔU ? We don't know how much heat left the system, so we can't determine whether $\Delta U = 0$ (heat leaving system = work done on system) or there was a net addition or loss of energy to the system via gain or loss of heat.